ADAM HILGER, LTD.

MARCH 1920

INDEX OF SECTIONS

All wavelengths are expressed in microns (μ) or in micromillimetres ($\mu\mu$)

The following Section is not included in this Volume, but will be sent post free on application

In addition to the instruments described in this Catalogue, the following, chiefly of value in the industrial applications, are described in separate booklets which we shall be pleased to send post free upon application:—

Abbe Refractometer.
Saccharimeter.
Strain-viewer for Glassware.
Glass Annealing Testing Bench.
Projection Comparator.

SECTION C.*

SPECTROMETERS AND GONIOMETERS FOR GENERAL WORK.

Those on pp. C 1 to C 4 can be used either as Goniometers or Spectrometers.

TABLE SPECTROMETER No. C 1 (formerly known as No. 1 A).

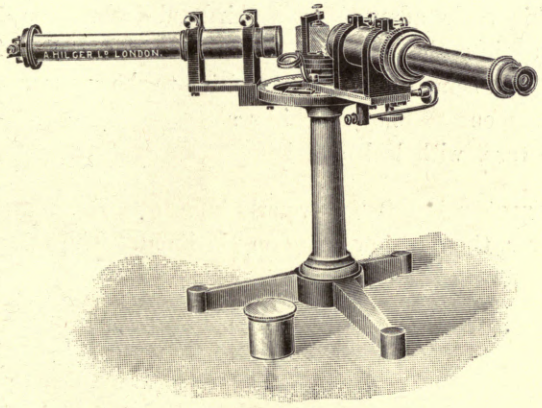

Fig. C 1.

This instrument is built in a very strong and simple way, and will stand hard use well. The divided circle, vernier, and the jaws of the slit are of platinoid, which is almost untarnishable.

Specification :—

Slit, No. F 24, p. F 5.

Object Glasses of Collimator and Telescope, $1\frac{1}{4}$ inch ($31\frac{1}{2}$ mm.) clear aperture, $11\frac{1}{4}$ inches (285 mm.) focal length.

The Focus of the Collimator is accurately set and fixed; the telescope focusses by helical motion.

Prism, $1\frac{5}{16}$ inch (33 mm.) high; $1\frac{5}{8}$ inch (41 mm.) length of refracting faces; refractive index for D 1·65.

Divided Circle, 6 inches diameter, divided all round to read by vernier to 1 minute of arc. The division is on platinoid, which is almost untarnishable.

Prism Table rotates, has a clamp for the prism, and a division every two degrees.

Eyepiece.—One eyepiece is supplied, with cross webs. The cross webs are capable of a slight lateral movement by means of a milled head screw, whereby one can very readily set the instrument to repeat exactly readings which may have been taken some time before.

Tripod, strong, of enamelled cast iron.

(*C 1*) **Price** ... ...
(*C 2*) Protective cover to prism table ... ...
(*C 3*) Levelling screws ... ...
(*C 4*) Photographic scale adapted on a third tube, the scale being reflected into the telescope from the second surface of the prism, and being seen in juxtaposition to the spectrum ...
(*C 5*) Screw adjustment to photographic scale ... ...
(*C 6*) Well-made case, with lock and key ... ...

Table Spectrometer No. C 7 (formerly known as No. 2).—The divided circle is 8 inches in diameter, the division being on platinoid. The telescope vernier reads

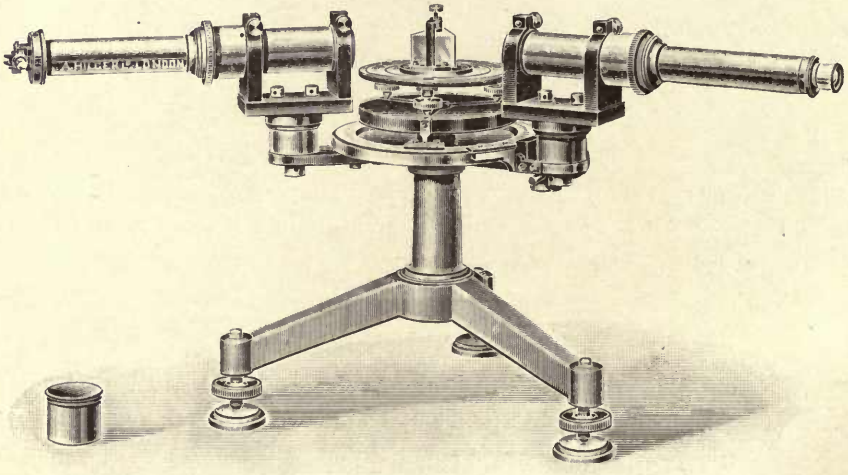

Fig. C 7.

to 30 seconds of arc. The prism stands on a separate levelling table, 6 inches in diameter, which is worked optically flat and stands on three levelling screws which fit in radial grooves in the rotating prism table. This latter reads by vernier to 30 seconds. One flint prism is supplied, refractive index for D 1·65. The prism

is in a separate mount, and can at once be placed in its correct position on the prism table. The collimator has a well-made adjustable slit (*see* Section F of "Spectroscopic Accessories," Slit No. F 24, p. F 5), with platinoid jaws, wedge for reducing the aperture, comparison prism, and protective cap. The telescope is supplied with high and low power eyepieces, cross spider webs for measurement, and steel tangent screw for slow motion. Both telescope and collimator have helical focussing adjustment. The objectives are of $11\frac{1}{4}$ inches (285 mm.) focal length, and $1\frac{1}{4}$ inches ($31\frac{1}{2}$ mm.) clear aperture. The fittings of collimator and telescope are secured by double clamps. The above is mounted on a stable iron tripod stand with three levelling screws.

(*C 7*) Price .. ..

(*C 8*) Photographic scale on a third tube uniform in design with telescope and collimator .. ..

(*C 9*) Screw adjustment to photographic scale .. .. ..

(*C 10*) Well-made case, with lock and key .. ..

Table Spectrometer No. C 12 (formerly known as No. 5), designed with special reference to accurate measurement of angles.—The mechanical work, centring of fittings, etc., is of the highest degree of perfection. The divided circle is 10 inches in diameter,

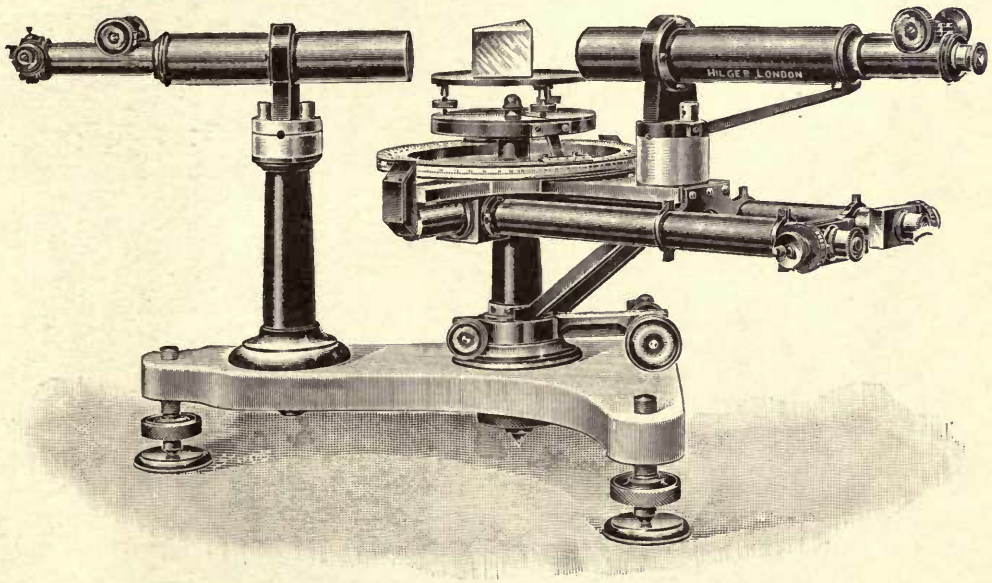

Fig. C 12.

and can be rotated to eliminate errors of the division. The circle has two divisions on platinoid, one on the top, on which the prism table reads to 30 seconds of arc by vernier, and one on the edge, on which the telescope reads by two microscopes, each with high quality micrometer eyepiece, to 1 second of arc. By a system of reflecting prisms

the micrometers are read from the eye end of the telescope. The levelling table for prisms is worked optically flat, and stands on three levelling screws in three radial grooves in the rotating table. This has a slow motion by rack and pinion. One large dense flint prism is supplied. The collimator has a high quality slit, which is adjustable by a good steel screw with large divided drumhead, wedge for varying the aperture, comparison prism, and screws for correcting any want of parallelism of the jaws which may develop in course of time. The collimator is supported on a separate pillar rising direct from the base. The telescope fitting consists of a 6-inch long sleeve fitting on a fine ground steel spindle, on which are also turned the fittings for the circle and prism table. The greatest care is taken to ensure that the fittings for the telescope circles and prism table are accurately coaxial. The telescope is well stayed, and is exceedingly rigid. Three eyepieces are supplied, each with cross webs. Both collimator and telescope have rack and pinion focussing and divided draw tubes (millimetre division). The objectives are of $1\frac{5}{8}$ inches clear aperture and of $14\frac{1}{2}$ inches focal length. The slow motion of the telescope is obtained by the action of a steel screw against a radial arm, which is attached to a split ring fitting on the sleeve carrying the telescope, and it can be put in or out of action by a clamp. The base is of cast-iron, very massive and rigid, with levelling screws standing in cups.

(*C 12*) Price ... ...

For Accessories for the above Spectrometers, see Section F, "Accessories for Spectrometers and Spectrographs."

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March 1920.

SECTION D.*

WAVELENGTH SPECTROMETERS.

INTRODUCTION.

The Wavelength Spectrometer introduced by us in 1904, and described in its most recent form on pp. D 1 to D 3, has been found useful for a large variety of purposes. A number of additions greatly extending the range of work which can be undertaken are fully described in Sections D and F of the Catalogue.

The selection of any such accessories must be determined by the work in view, but we give below a list which may assist such selection. In each case the Spectrometer given in the list is the *Hilger Wavelength Spectrometer*, with dense prism (pp. D 1 to D 4).

LIST SUITABLE FOR A CHEMICAL LABORATORY.

		See pages.	Price.	Purposes for which useful.
(*D 2*)	Spectrometer . . .	D 1–4		General spectrum analysis.
(*D 10*)	*Camera*	D 3–4		
(*D 10 & 11*)	*Camera*, if with mirror and telescope . . .	D 4		
(*F 25*)	*Sliding diaphragm*, to slit with three apertures instead of wedge. .	F 5		
(*F 40–41*)	*Shutter eyepiece* and slide with light filters . .	D 3		
(*D 7*)	*Extra high power* eyepiece.	D 3		
(*F 6 & F 10*)	*Slit rod and Carrier*, with sphero-cylindrical glass condenser . . .	F 2		
(*F 3*)	*Combined Vacuum* tube holder and spark apparatus	F 1		
(*F 4*)	*Arc lamp*, for metals .	F 1		

LIST SUITABLE FOR A CHEMICAL LABORATORY—continued.

	See Pages.	Price.	Purposes for which useful.
(*F 119*) *Nutting Photometer*, with 2 tubes for liquids and stand for same.	F 4		All kinds of Spectrophotometry; quantitative estimation of coloured salts, dyes, and organic substances possessing suitable absorption bands when in solution.

For a Physical Laboratory the following are useful in addition to the above:—

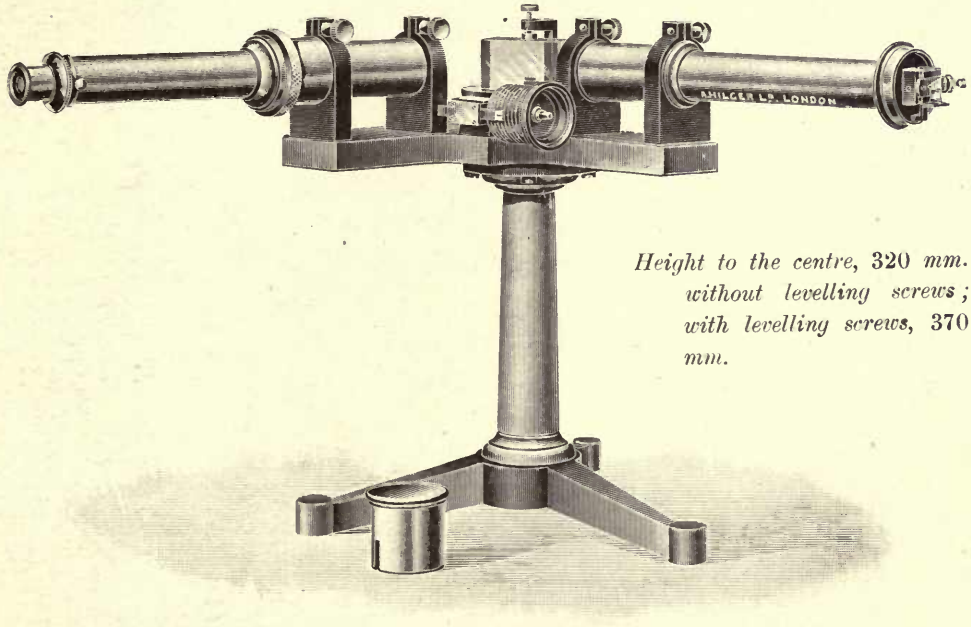
(*O 8 or O 10*) Spectrometer of modified form for high resolving power accessories described in Section O	D 1–4 O 4–5		Zeeman effect, and other work requiring high resolving power.
(*O 2*) *Michelson Echelon* . .	O 1 and 2		
(*O 3*) *Lummer-Gehrcke* plate .	O 2		
(*O 6*) *Fabry & Perot* etalon .	O 3		
(*O 14*) *Small electromagnet* for showing the Zeeman effect	O 7		
(*O 15*) [1] *Shutter eyepiece* with polarising prism for observing the Zeeman effect	O 7		

[1] If this shutter eyepiece be ordered, it is unnecessary to purchase the one described above.

THE HILGER WAVELENGTH SPECTROMETER,
Constant Deviation Type.

THE design of this instrument (Fig. D 1, D 2) is based on the use of the well-known "constant deviation prism." There are a number of different forms of this prism, of which the one used on the Hilger Wavelength Spectrometer is shown in Fig. D 1 A. It may be considered as built up of two 30° prisms and one right-angled prism from the hypotenuse of which the light is internally reflected as shown.

The telescope and collimator are both rigidly fixed, since to pass through the spectrum it is only necessary to rotate the prism; and as a result a construction is arrived at which is at once extremely convenient and mechanically sound.



Height to the centre, 320 *mm. without levelling screws; with levelling screws,* 370 *mm.*

Fig. D 1, D 2.

The table on which the prism stands is rotated by means of a fine steel screw, the point of which pushes against a projecting arm on the prism table. To the screw is fixed a drum (*see* Fig. D 1 B) on which the wavelengths of the line under observation are read off direct as indicated by the index which runs in a helical slot. In the most recent instruments this index is on the side of the drum towards the eye; so that the wavelengths of lines can be read off without quitting the eyepiece (*see* Fig. D 1, D 2). The point of the micrometer screw is of hardened steel, and is permanently fixed before the screw thread is cut, to avoid the risk of periodic errors, the point forming one of the centres whilst the screw thread is being cut. This hardened steel

point presses against a steel plug in the above-mentioned projecting arm of the prism table, itself flint-hard and *optically polished.*

The telescope and collimator are both rigidly fixed to the cast-iron base, and the whole is screwed to a strong cast-iron tripod. The object glasses of both telescope and collimator are of $11\frac{1}{4}$ inches (285 mm.) focal length, and $1\frac{1}{4}$ inches ($31\frac{1}{2}$ mm.) clear aperture.

It will be seen that the design is extremely strong and simple ; and the accuracy is as great as that obtainable by the use of the very highest class of divided circle spectrometer (unless recourse is had to careful line-to-line measurements with a micrometer eyepiece or some similarly laborious process), whilst in point of ease, speed, and convenience the "Wavelength" form is vastly superior.

The focussing of the telescope is obtained by the milled ring, which can be seen in the figure on the body of the telescope. By the turning of this ring the object glass is made to move by a carefully protected helical mechanism, the eyepiece remaining always fixed. By this means a more accurate focussing adjustment is obtained, without the liability to a sideway shift of the lines due to the focussing, which it is impossible entirely to avoid in the older form.

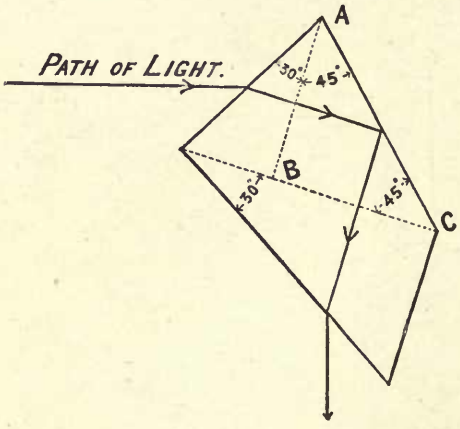


Fig. D 1 A.

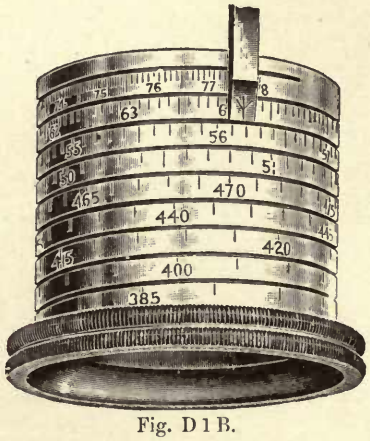


Fig. D 1 B.

Price :—

(*D 1*) Wavelength Spectrometer, prism of 1·65 refractive index for D, accurately calibrated from 385 $\mu\mu$ to 800 $\mu\mu$ [1] ... ..

(*D 2*) With denser prism, 1·74 refractive index for D, and correspondingly increased accuracy of calibration, the calibration being from 390 $\mu\mu$ to 800 $\mu\mu$ [1] ... ...

---

[1] With the prism of 1·65 refractive index for D, the Helium line 3888·8 and the Lithium line 8127 can both be seen. With the prism of 1·74 refractive index for D, the Helium line is not visible, but the Calcium lines 3968·6 and 3933·8, and the Aluminium lines 3961·7 and 3944·2 are visible in the light of a carbon arc fed with lime and alumina ; while at the red end the Lithium line is easily visible.

(*D 4*) Protective cover to prism table ... ...

(*D 5*) Levelling screws ... ...

(*D 6*) Well-made case with lock and key, for either of the above ...

(*D 7*) Extra high-power eyepiece, with its own zero adjusting cross-webs

(*F 40*) Shutter eyepiece with lateral adjustment to bright pointer (*see* Fig. F 40, and description below) ... ...

(*F 41*) Slide with light filters to the shutter eyepiece for giving the pointer any desired colour, by means of which an increase of accuracy and comfort in reading can be secured, especially in the violet part of the spectrum ... ...

NOTE.—This eyepiece has two shutters, which can be shifted from either side in the focal plane so as to cover any desired part of the field, thereby obscuring any bright lines which by their proximity prevent the observation of feebler lines. The metal pointer, whose extremity is ground exceedingly fine and polished bright with the greatest care, is illuminated from above by a mirror. This bright pointer is adjustable laterally by the two milled head screws below, so that one can always return to the standard reading by setting the bright pointer on a reference line.

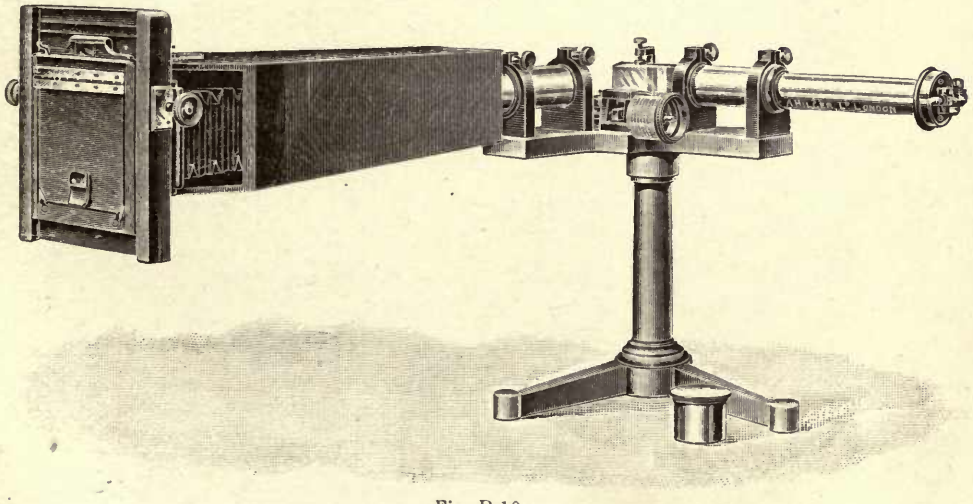


Fig. D 10.

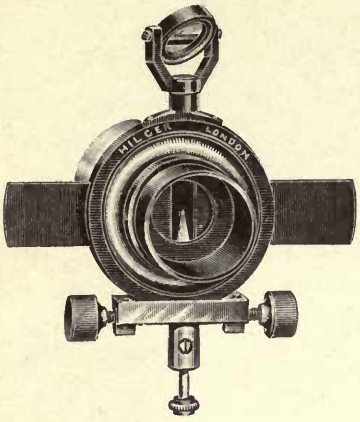


Fig. F 10.

(*D 10*) Camera, with 21-inch focus lens, tilting adjustment for accurately focussing the whole spectrum, and shutter for exposure (shown in position in Fig. D 10) ... ...

(*D 11*) Telescope fixed to side of the camera, and internal mirror with external milled head by means of which the spectrum can be reflected into the telescope at will. In this way the spectrum can be observed immediately before photography. The telescope is on the collimator side of the camera, so that the slit, wavelength drum, and light source are all within reach of the observer. Price ...

Replica of Rowland diffraction grating, as described on pp. D 7–8, interchangeable with the prism.

(*D 12*) Price, including calibration in wavelengths for both prism and grating

NOTE.—*This can only be supplied if ordered at the same time as the Spectrometer.*

We can now supply for these Spectrometers apochromatic triple object glasses. The calculations for these lenses and the measurements of the refractive indices of the glasses used have been made by J. W. Gifford, Esq.

Clear Aperture	32 mm. ($1\frac{1}{4}$″).
Equivalent Focal Length ..	280 mm. ($11\frac{1}{4}$″).

(*D 13*) Price adapted to the Wavelength Spectrometer in place of the usual achromatic doublet object glasses, extra ... ...

For other accessories, see *Section F*, "*Accessories for Spectrometers and Spectrographs.*"

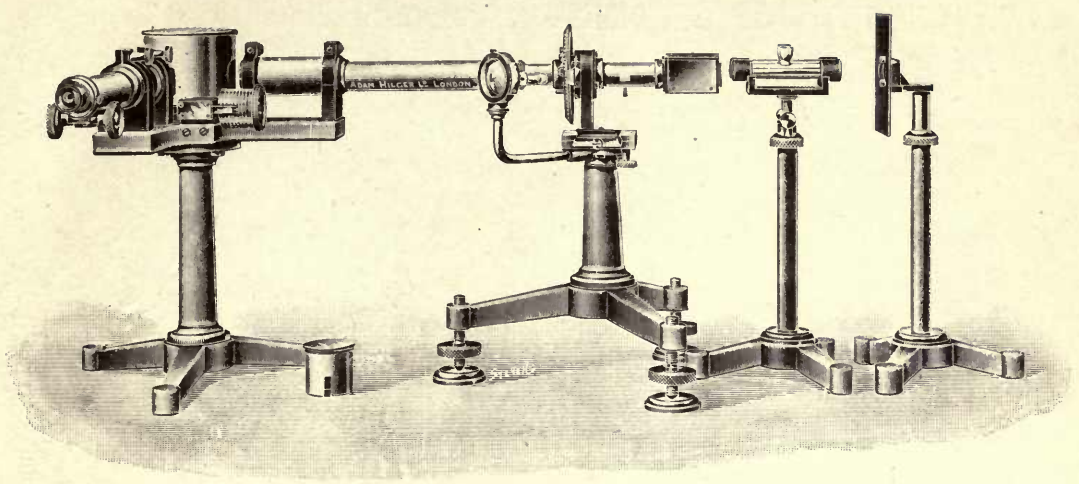


Fig. D 1 or D 2, F 119.

The above figure shows the Hilger Wavelength Spectrometer used with the Nutting Photometer.

(*F 119*) **Nutting photometer** on separate stand (as described on p. F 4 and shown in Fig. D 1, F 119), extra ... ...

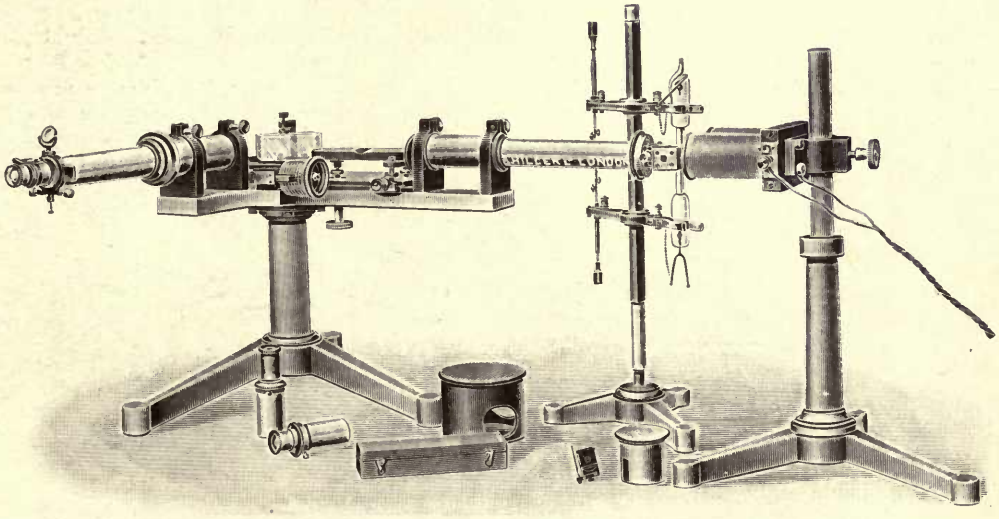
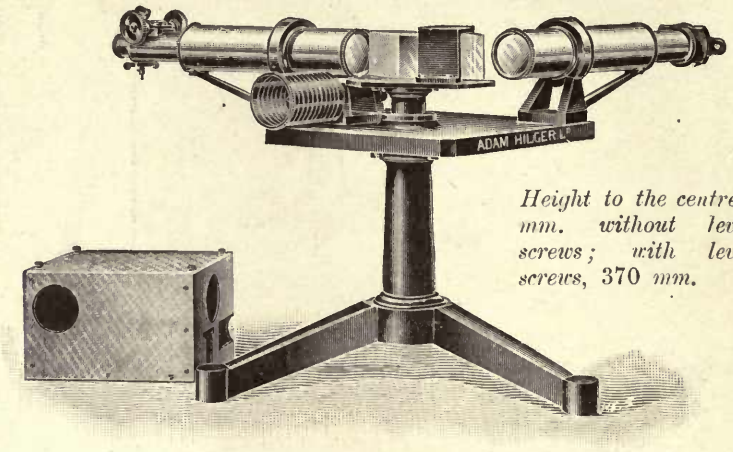


Fig. O 8 or O 10, O 3, F 3, and O 14.

The above figure shows the Hilger Wavelength Spectrometer arranged for use with Fabry-Perot etalon, etc. (see *Section O*)*; with Lummer-Gehrcke parallel plate in position as set up for observing the Zeeman effect.*

WAVELENGTH SPECTROMETER, Constant Deviation Type (Large Model).



Height to the centre, 320 mm. without levelling screws; with levelling screws, 370 mm.

Fig. D 19.

Wavelength Spectrometer, Constant Deviation type, large Model.—This instrument (Fig. D 19) reads with an average accuracy of about 1 Ångström unit, from 388·8 to 795·0 $\mu\mu$ in wavelengths direct. The principles of its construction are the same as that of the smaller model, but it is larger and more powerful in every way. The object glasses are of $1\frac{5}{8}$-inch ($41\frac{1}{2}$ mm.) clear aperture, and of $14\frac{1}{2}$ inches (368 mm.) focal length. The divided scale of wavelengths is engraved on a helical drum, the length of scale division being about 81 inches (205 cm.). The eyepiece has a bright pointer for measuring the wavelengths of bright spectrum lines on a dark field. The instrument is of the Constant Deviation Type—*i.e.*, the telescope and collimator are both rigidly fixed, the spectrum being traversed by the fine micrometer screw to which the helical drum is attached. The index is on the side of the drum towards the eye, so that the wavelengths of lines can be read off without quitting the eyepiece.

(*D 19*) Price, including shutter eyepiece with bright pointer and lateral adjustment (*see* Fig. F 40), and calibrated complete ... ...

NOTE.—*We can also supply this instrument with a smaller screw motion, and less extended wavelength scale engraved on a drum identical with that on the Wavelength Spectrometer with Diffraction Grating (Fig. D 25). The accuracy is then the same as that of the small instrument with dense prism, but the intensity of illumination is nearly double.*

(*D 20*) *Price* ... ...

(*D 21*) Levelling screws to either of the above ... ...

(*D 22*) Well-made mahogany case, with lock and key to either of the above ... ...

(*D 23*) Camera to go in place of the telescope, with $21\frac{1}{2}$-inch focus lens, extra to either of above ... ...

(*D 24*) Apochromatic triple object glasses, instead of the doublets usually supplied, extra to either of the above ... ...

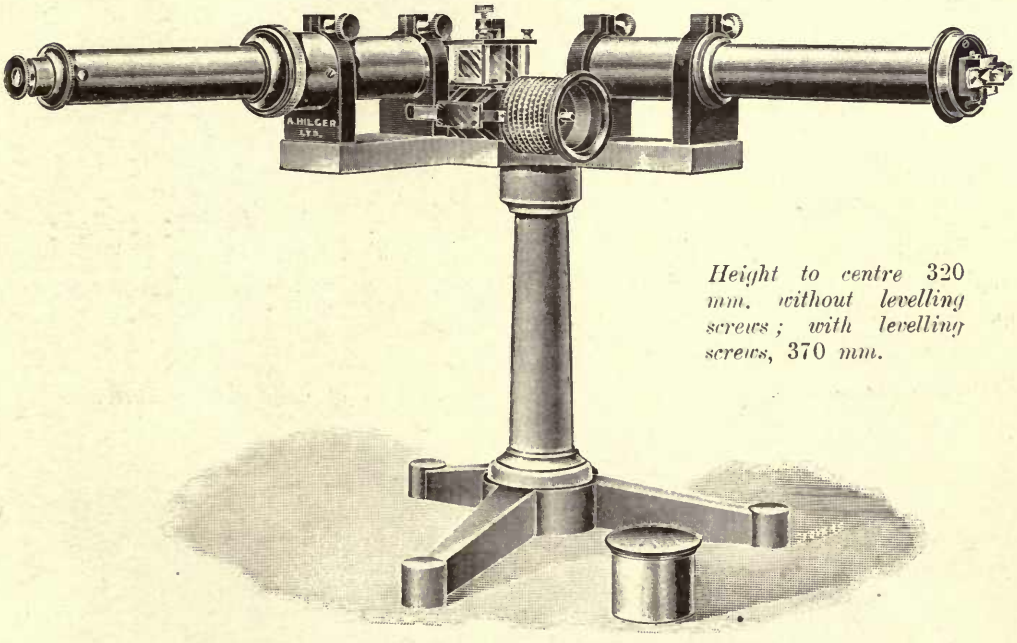
For further accessories, see *Section F, "Accessories for Spectrometers and Spectrographs."*

HILGER WAVELENGTH SPECTROMETER, with Diffraction Grating.

(*Resolves the 4 doublets of the E Group, and measures wavelengths to 1 Ångström Unit.*)

THIS Spectrometer (Fig. D 25) has been designed with a view to supplying the demand for an instrument giving a greater accuracy of wavelength measurement than does our well-known Wavelength Spectrometer, Constant Deviation type with prism, to which it is similar in construction; and is suitable for use in all cases where the amount of light available is sufficient.

The accuracy of the instrument is about $2\frac{1}{2}$ times that of the dense prism instrument, the readings being accurate to 1 Ångström unit throughout the spectrum.



Height to centre 320 *mm. without levelling screws; with levelling screws,* 370 *mm.*

Fig. D 25.

Of this instrument and the prism instrument each has its peculiar advantages, the former on account of its higher accuracy, and the latter on account of the brightness of the spectrum making it suitable for the examination of the very faintest lines.

The diffraction grating, which is a carefully selected film replica of one of Rowland's metal diffraction gratings, is mounted on a right-angle prism from the

hypotenuse of which the light is totally reflected. By this means one can pass through the spectrum by rotation of the table on which the prism stands, as in the case of the instrument described on pp. D 1 and 2. The telescope and collimator and general build are also similar to those of that instrument. The wavelength drum and index are shown in Fig. D 25 A.

(*D 25*) Price of this Spectrometer, accurately calibrated in wavelengths throughout the whole visible spectrum from 380 $\mu\mu$ to 800 $\mu\mu$ (including cover to prism table) ...

(*D 26*) Additions to convert into the prism instrument described on pp. D 1 and 2, with wavelength graduations for both grating and prism scales, and wooden case for keeping prism and grating when not in use ...

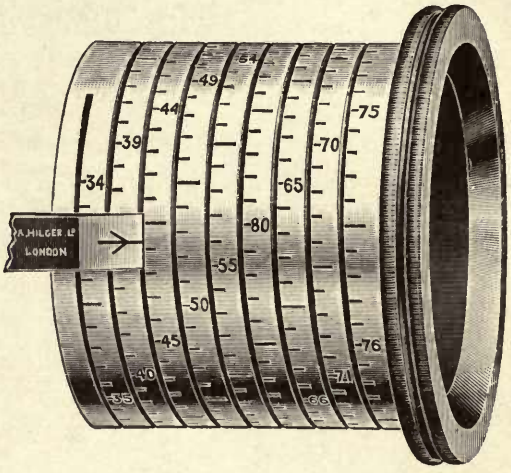


Fig. D 25 A.

NOTE.—*These can only be supplied if ordered at the same time as the Spectrometer.*

The following additions can be supplied with this instrument:—

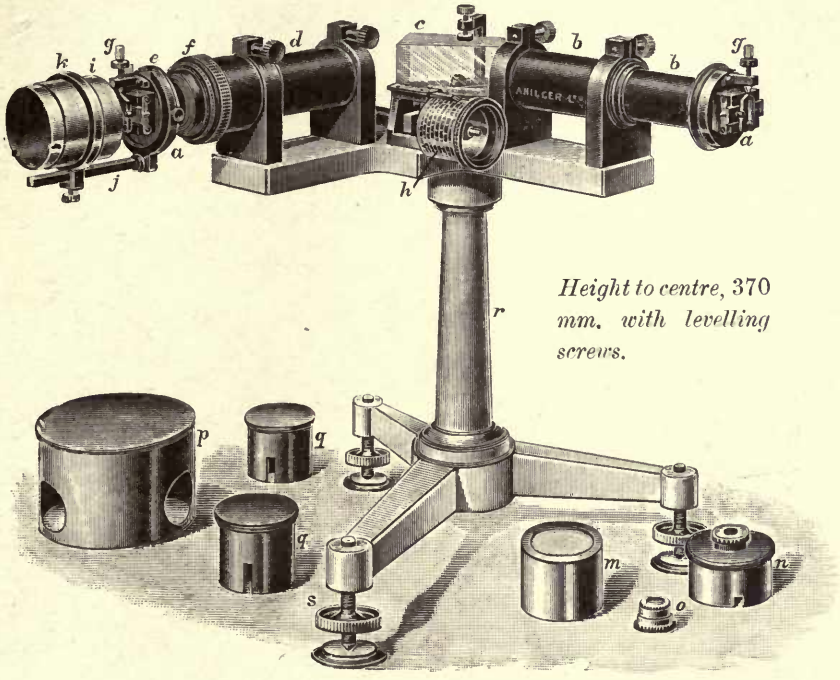
Levelling screws, case with lock and key, extra high power eyepieces, shutter eyepiece, and camera. For prices and descriptions, *see* under the prism instrument, pp. D 3 and D 4.

For further accessories, see *Section F, "Accessories for Spectrometers and Spectrographs."*

DR TUTTON'S SPECTROSCOPIC MONOCHROMATIC ILLUMINATOR.

Aperture ratio f/6.

This instrument (Fig. D 32) is described and illustrated in Dr Tutton's "Crystallography" (Macmillan & Co., 1911), and performs very efficiently the same functions as the Spectroscopic Monochromatic Illuminator described by Dr Tutton to the Royal Society in 1895 (*Phil. Trans. A*, 185, 913), an illustrated account of which is also given in his "Crystalline Structure and Chemical Constitution"



Height to centre, 370 mm. with levelling screws.

Fig. D 32.

(Macmillan & Co., 1910). It is similar in construction to the Hilger Wavelength Spectrometer (prism form) described on pp. D 1 to D 4, with the following modifications:—

(1) The addition of a second adjustable and *symmetrically opening* slit which can be put in the place of the eyepiece, thus converting the instrument into a Monochromatic Illuminator. The first slit is also made *symmetrically opening*.

(2) The prism (of 1·62 refractive index for D) is of larger size, giving an effective beam of light 30 mm. wide for 589 $\mu\mu$.

(3) The object glasses are 31·5 mm. clear aperture; but to increase the intensity of the light the focal length is reduced to 185 mm.

(4) The eyepiece may be attached in front of the second slit, for observation of the spectrum lines and regulation of the opening of the slit.

(5) One of two alternative ground-glass diffusing screens is mounted on an

adjustable tubular fitting in front of the second slit, adequately to diffuse the issuing monochromatic light so as to fill the field of any observing instrument brought in front of it.

The wavelength drum is engraved from λ 385 $\mu\mu$ to λ 800 $\mu\mu$.

(*D 32*) Price, including the usual accurate wavelength calibration and protective cover for the prism table ... ...

In the case of certain classes of work for which this instrument may be used requiring greater intensity of light, a suitable lens may be mounted in place of the ground glass screen; but for convenience and efficiency in crystallographic observations Dr Tutton has found the diffusing screens greatly superior.

MONOCHROMATIC ILLUMINATOR FOR THE ULTRA-VIOLET AND VISIBLE, reading from 200 $\mu\mu$ to 700 $\mu\mu$ direct in Wavelengths.

(Can be calibrated with a Frequency or Frequency^2 Scale if desired.)

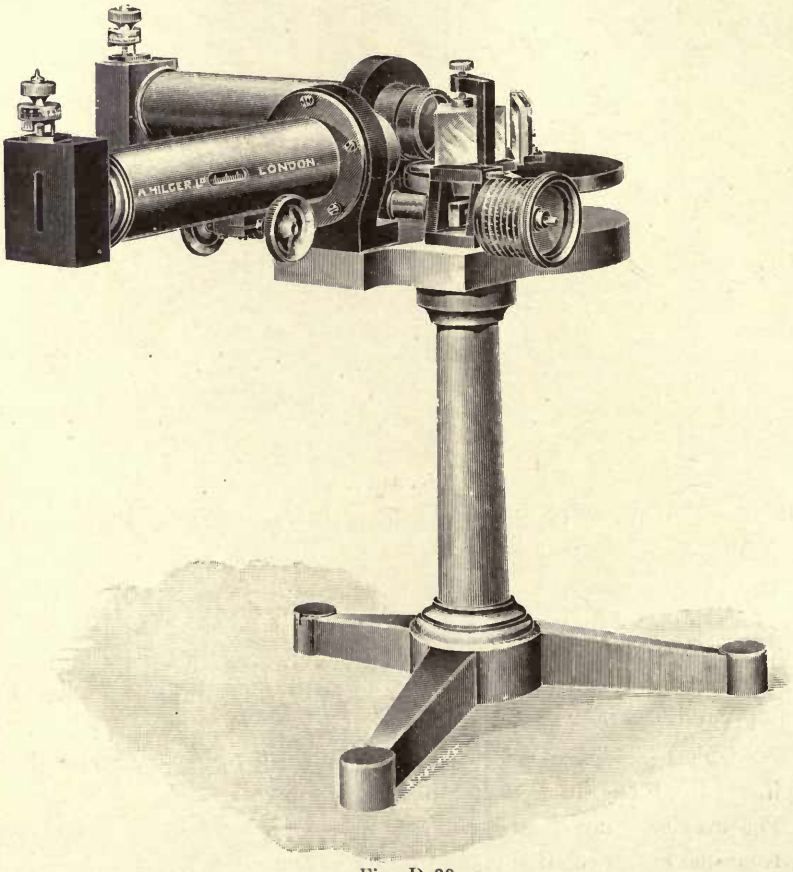


Fig. D 33.

This instrument (Fig. D 33), which is particularly suitable for experiments on

the photo-electric effect, etc., is shown in the above illustration. Levelling screws are always supplied, although not shown in the figure.

The lenses are of 31 mm. aperture and 210 mm. focal length for $\lambda = 300\ \mu\mu$.

The beam of light from the collimator passes at minimum angle through a Cornu prism of quartz (height 32 mm., length of face 42 mm.), and is then reflected from a plane mirror into the telescope. The mirror consists of a plane parallel plate of quartz coated on the back with mercury tinfoil amalgam, which is an excellent reflector in the ultra-violet. The prism and mirror stand on one table, which is rotated by means of a fine steel screw in the same way as the prism table of the Wavelength Spectrometer, Constant Deviation type (*see* pp. D 1 to D 4), the wavelength of the portion of the spectrum under observation being read off direct on a helical drum.* The average accuracy of reading throughout the range is about 1 $\mu\mu$. The collimator and telescope are rigidly fixed to the cast-iron base. If desired, a quartz prism on the constant deviation principle can be supplied, but owing to the greater thickness of quartz traversed with such a prism, and the fact that the absorption of quartz begins to be important even at wavelength 202 $\mu\mu$, this form is not recommended.

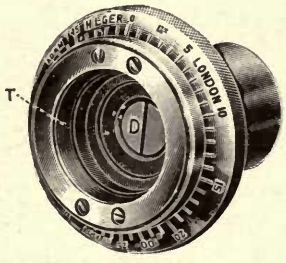


Fig. D 33 A.

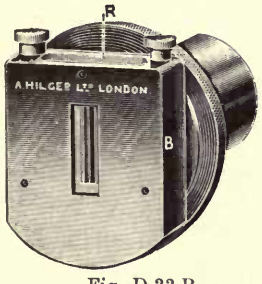


Fig. D 33 B.

The improved symmetrical slits supplied on these instruments and on the infra-red spectrometer are shown in Figures D 33 A and D 33 B.

Slit 33 A, for the collimator, is provided with a screw-thread T in front of the slit, into which is screwed a diaphragm of 11 mm. aperture. If it be desired to utilise the entire length of the slit this diaphragm can be removed. The screw thread forms a ready means of adapting an eyepiece to the slit, an arrangement which is often convenient.

Slit 33 B for the telescope differs from slit A only in having a block B with recess R for thermopile, and an eyepiece (removed in the illustration) for observation of the slit and thermopile. This block is no hindrance to the use of the slit for the monochromatic illuminator.

Both the above slits are adjustable by large milled ring, with division reading to 1/1000 inch.

(*D 33*) Price ... ...

* *See note on p.* D 14.

For quartz-condensing lenses, fluorescent eyepiece, etc., *see* Section F.

The dimensions of the optical parts of this instrument have been adopted as having been found suitable for work on the photo-electric effect; we are, however, prepared to quote, if required, for instruments of similar construction but with larger prisms and larger diameter lenses up to $f/4{\cdot}5$ in quartz, or if purity of spectrum can be sacrificed, lenses of the standard diameter but of focal aperture $f/4{\cdot}5$ can be supplied. For such large focal apertures it is desirable to use in front of the slit a special quartz condenser figured to remove spherical aberration.

Additions for converting the above Instrument into the Infra-red Spectrometer, described on p. D 13, consisting of:—

Rocksalt prism, concave mirrors of gold electro-deposited on glass, plane mirror to replace that used for the ultra-violet, thermopile to fit into slit 33 B above, extra helical drum calibrated for the infra-red, cast-iron base and mounting for the symmetrical slits and mirrors, and case to take the ultra-violet or infra-red portions of the apparatus when not in use.

When it is desired to use the apparatus for infra-red work, it is only necessary to remove the telescope and collimator, to replace the quartz prism by that of rocksalt, and to attach the cast-iron frame on which the mirrors are mounted with the symmetrical slits in position thereon.

(*D 34*) Price of the complete infra-red attachments ... ...

For suitable galvanometer for use with the above infra-red attachments, see *p.* F 11 *of our Catalogue.*

INFRA-RED SPECTROMETER.

Calibrated in Wavelengths from 500 $\mu\mu$ to 9000 $\mu\mu$.

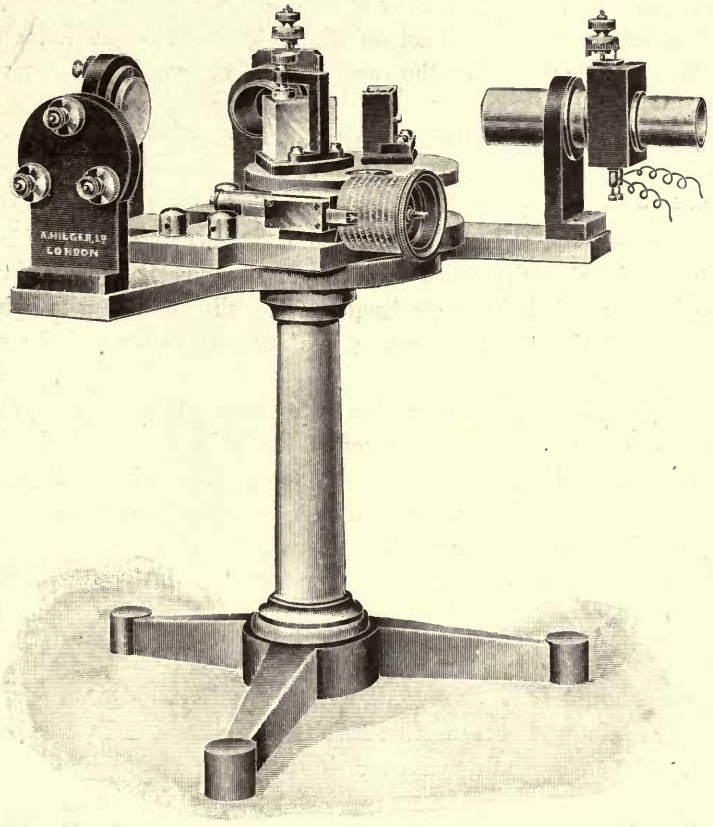


Fig. D 35.

The optical elements of the Infra-red Spectrometer shown in Fig. D 35 are as follows :—

Two symmetrical slits, each having an effective length of jaws of 20 mm. In the second of these slits is mounted a Hilger thermopile (fully described on pp. F 10 and *F* 11).

Two concave mirrors of gold electro-deposited on glass, both of 27 cms. focal length and 38 mm. diameter.

Rocksalt prism 32 *mm.* high, 42 mm. length of face.

Plane mirror of gold electro-deposited on glass.

The two slits and the two concave mirrors are rigidly fixed to a cast-iron base.

Levelling screws are supplied to the tripod, although they are not shown in the figure.

The light entering from the first slit is collimated by the first mirror, and passes through the rocksalt prism to the plane mirror. It is reflected thence to the second concave mirror, by which an image of the spectrum is formed on the second slit.*

The rocksalt prism and plane mirror are mounted on a table which is capable of rotation by a fine screw. To this screw is attached a drum on which the wavelength of the line under observation is read off direct by means of an index running in a helical slot in the same way as in the case of the Wavelength Spectrometer described on pp. D 1–2.

The entire thermopile case is protected from external radiations by a large nickel-plated case.

The thermopile will be supplied with a sensitive area 10 mm. long × 1 mm. wide unless otherwise ordered. If desired the 20 mm. long × 1·5 mm. wide size can be supplied, the price being the same. The larger size gives, of course, larger galvanometer deflections (provided the whole length of the slit be filled with light), but owing to the curvature of the spectrum lines a less accurate reading of the wavelength is obtainable.

The rocksalt prism is varnished with a solution of pyroxylin in amyl acetate unless special instructions are given to the contrary. This varnish, while protecting the prism, allows most of the infra-red rays in the region over which this spectrometer is calibrated to pass almost unabsorbed. It has one strongly-marked absorption band, but if necessary it can easily be washed off with amyl acetate.

(*D 35*) Price of the Infra-red Instrument complete, as described, with levelling screws ... ...

(*For suitable galvanometer see* p. F 11.)

(*D 36*) Price of additions necessary to convert the Infra-red Spectrometer into the Monochromatic Illuminator described on pp. D 10–12, including case for the parts not in use ...

A leaflet of instructions as to the use of the infra-red spectrometer is issued with each instrument. This leaflet also contains notes concerning the method and accuracy of the calibration, care of the prism, the dispersion of rocksalt, and the results of an investigation into some sources of error.

---

* This arrangement, in which every ray when in the position of observation passes through the prism at minimum deviation, was first described by Wadsworth, *Phil. Mag.* (5), *38*, 346 (1894).

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Cable Code—Western Union.

March 1920.

SECTION E.*

SPECTROGRAPHS.

Specimen photographs taken on any of the Spectrographs mentioned in this Section will be sent post free on application.

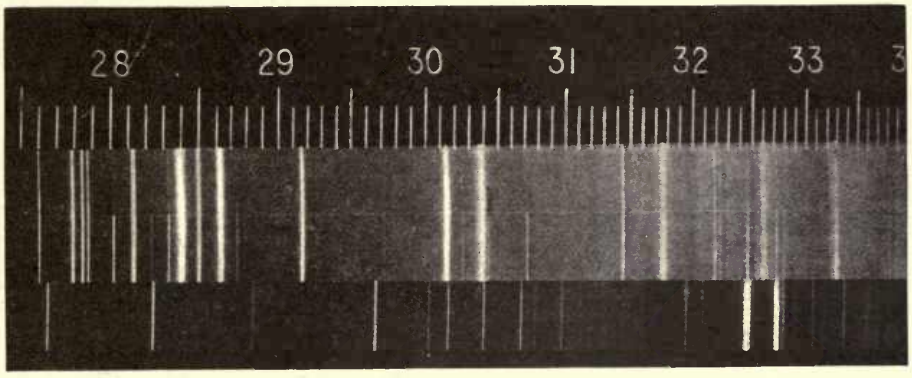

Fig. E 1 A (*enlarged three times*).

UNLESS a special desire is expressed to the contrary, we now supply on the slits of the spectrographs described on pp. E 2 to E 4, in place of the usual comparison prism, a sliding diaphragm, interchangeable with the wedge of the slit, this diaphragm having three apertures giving three comparison spectra in close juxtaposition.

The above print is a process reproduction, enlarged three times, of a portion of a photograph of three comparison spectra taken in this manner on our quartz spectrograph, size E 2 (formerly known as size C), with wavelength scale (*see* p. E 3).

In addition to those described in this Section, other forms of spectrograph made by us are the "Littrow" spectrographs (either with plane diffraction gratings or with prism systems) of 8 feet (Section G) and of 10 feet focal length; and quartz spectrographs of large aperture ratio (up to *f*/5); while for work in the visual spectrum not requiring great resolving power, the wavelength spectrometers with cameras described in Section D should also be taken into consideration. Prices, and specimen photographs taken on any of these, will be sent post free on application.

Photographs of Samples.—We are prepared to take photographs of the spectra of samples on one of our quartz E 2 (formerly known as size C) spectrographs, with wavelength scale, at a charge of for each photograph. The spectra of three samples, together with the wavelength scale, as shown above, can be taken for this price.

For micrometers for use with these spectrographs, see *Section L.*

For other accessories for spectrographs, including photographic plates, see *Section F.*

Levelling screws are supplied to the tripod, although they are not shown in the figure.

The light entering from the first slit is collimated by the first mirror, and passes through the rocksalt prism to the plane mirror. It is reflected thence to the second concave mirror, by which an image of the spectrum is formed on the second slit.*

The rocksalt prism and plane mirror are mounted on a table which is capable of rotation by a fine screw. To this screw is attached a drum on which the wavelength of the line under observation is read off direct by means of an index running in a helical slot in the same way as in the case of the Wavelength Spectrometer described on pp. D 1–2.

The entire thermopile case is protected from external radiations by a large nickel-plated case.

The thermopile will be supplied with a sensitive area 10 mm. long × 1 mm. wide unless otherwise ordered. If desired the 20 mm. long × 1·5 mm. wide size can be supplied, the price being the same. The larger size gives, of course, larger galvanometer deflections (provided the whole length of the slit be filled with light), but owing to the curvature of the spectrum lines a less accurate reading of the wavelength is obtainable.

The rocksalt prism is varnished with a solution of pyroxylin in amyl acetate unless special instructions are given to the contrary. This varnish, while protecting the prism, allows most of the infra-red rays in the region over which this spectrometer is calibrated to pass almost unabsorbed. It has one strongly-marked absorption band, but if necessary it can easily be washed off with amyl acetate.

(*D 35*) Price of the Infra-red Instrument complete, as described, with levelling screws ... ...

(*For suitable galvanometer see* p. F 11.)

(*D 36*) Price of additions necessary to convert the Infra-red Spectrometer into the Monochromatic Illuminator described on pp. D 10–12, including case for the parts not in use ...

A leaflet of instructions as to the use of the infra-red spectrometer is issued with each instrument. This leaflet also contains notes concerning the method and accuracy of the calibration, care of the prism, the dispersion of rocksalt, and the results of an investigation into some sources of error.

---

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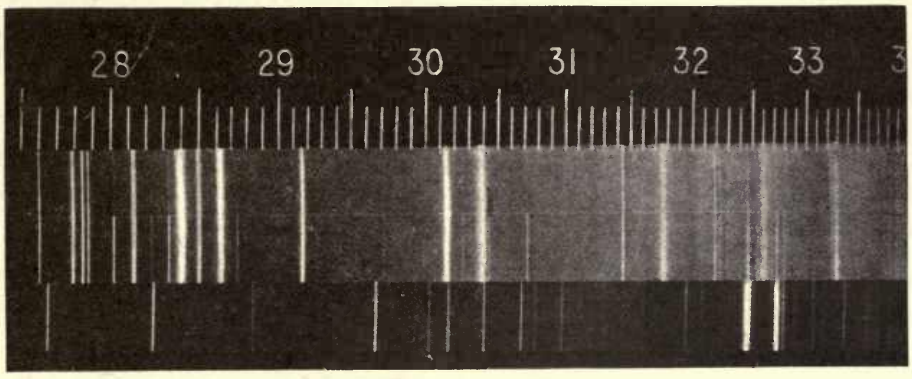

Fig. E 1 A (*enlarged three times*).

UNLESS a special desire is expressed to the contrary, we now supply on the slits of the spectrographs described on pp. E 2 to E 4, in place of the usual comparison prism, a sliding diaphragm, interchangeable with the wedge of the slit, this diaphragm having three apertures giving three comparison spectra in close juxtaposition.

The above print is a process reproduction, enlarged three times, of a portion of a photograph of three comparison spectra taken in this manner on our quartz spectrograph, size E 2 (formerly known as size C), with wavelength scale (*see* p. E 3).

In addition to those described in this Section, other forms of spectrograph made by us are the "Littrow" spectrographs (either with plane diffraction gratings or with prism systems) of 8 feet (Section G) and of 10 feet focal length; and quartz spectrographs of large aperture ratio (up to *f*/5); while for work in the visual spectrum not requiring great resolving power, the wavelength spectrometers with cameras described in Section D should also be taken into consideration. Prices, and specimen photographs taken on any of these, will be sent post free on application.

Photographs of Samples.—We are prepared to take photographs of the spectra of samples on one of our quartz E 2 (formerly known as size C) spectrographs, with wavelength scale, at a charge of for each photograph. The spectra of three samples, together with the wavelength scale, as shown above, can be taken for this price.

For micrometers for use with these spectrographs, see *Section L.*

For other accessories for spectrographs, including photographic plates, see *Section F.*

Vacuum Spectrographs.—We are now able to quote for Vacuum Grating Spectrographs for the Schumann and Lyman regions of the spectrum. Full particulars will be sent post free on application.

QUARTZ SPECTROGRAPHS.

Quartz Spectrograph, size E 1 (formerly known as size D), Fig. E 1.—This spectrograph has a dispersion three times that of size E 2, being designed for work with complex spectra, such as that of iron. It takes the entire spectrum from 210 $\mu\mu$ to 800 $\mu\mu$ in three exposures, on 10 × 4 inch photographic plates.

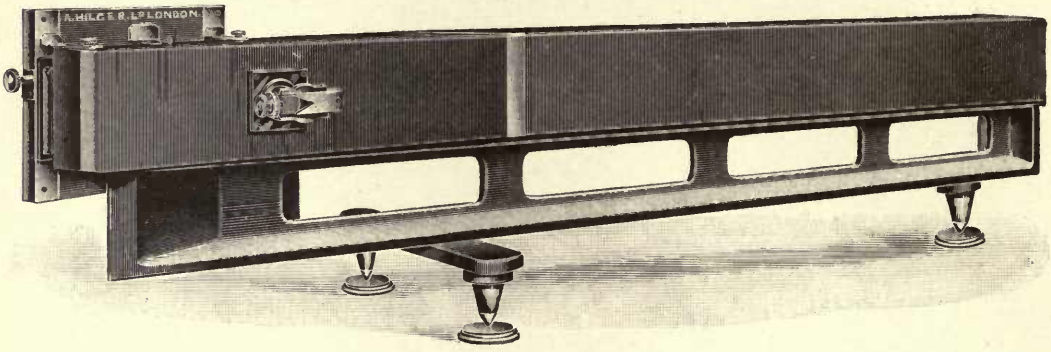

Fig. E 1.

It is of the "Littrow" form, which in so large an instrument presents great advantages owing to its compactness.

The optical train consists of one quartz lens of 70 mm. clear aperture, and 170 cms. focal length; and a 30° prism of quartz 98 mm. length of refracting face × 57 mm. high, the second face being coated with tin mercury amalgam, which is a good reflector throughout both the visual and ultra-violet regions.

The slit is our No. F 31 (*see* pp. F 5-6).

The light enters by the slit, is reflected along the camera tube by a right-angled prism of quartz, is collimated by the lens, enters and is reflected back by the quartz prism, and retraces its path through the lens, an image of the spectrum being formed on the photographic plate.

The prism and lens are mounted on a carriage which moves along a slide, its position being definitely determined by two stops with screw adjustment. The prism can also be rotated to one of three definite positions. These alternative positions correspond with the three portions of the spectrum; the camera being provided with means of varying the inclination of the plate necessary to obtain good definition throughout the spectrum.

The whole is mounted on a substantial cast-iron base.

Overall length of spectrograph 78·7 inches (2000 mm.).

Overall width of spectrograph 13·75 inches (350 mm.).

(*E 1*) Price ... ...

The following two spectrographs, with quartz prisms and lenses, have been very carefully designed with the following objects in view :—

(1) *To be in permanent adjustment.*
(2) *To give the whole spectrum from* 210 $\mu\mu$ *to* 800 $\mu\mu$ *on one plate.*
(3) *To give good definition over the whole spectrum on the ordinary photographic plate.*
(4) *To give as large an amount of light as is consistent with the above conditions, thus enabling spectrograms to be taken with relatively short exposures.*

The instruments are sent out completely adjusted, ready for photographs to be taken.

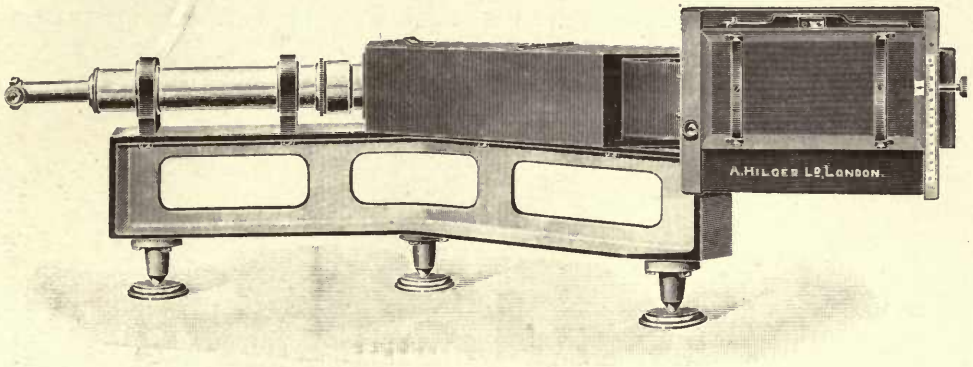

Fig. E 2.

Quartz Spectrograph, size E 2 (formerly known as size C) (*see* Fig. E 2).—Lenses of 24 inches (610 mm.) focus, the instrument giving a spectrum from 210 $\mu\mu$ to 800 $\mu\mu$ of about 200 mm. long. Prism, 41 mm. high × 65 mm. long face. Size of plate, 10 × 4 inches. The slit is our No. F 31 (*see* pp. F 5-6). The dispersing system consists of one Cornu prism. There is a vertical motion by rack and pinion to the dark slide, with scale, whereby a number of exposures can be taken one below the other.

(*E 2*) Price ... ...

(*Specimen photographs will be sent post free on application.*)

Quartz Spectrograph, size E 2, with wavelength scale.

In the case of the size E 2 instrument, an accurate scale of wavelengths can be mounted internally in such a manner as to be brought at will in contact with the photographic plate. Illumination is provided by means of a small electric lamp, and a contact print of the wavelength scale can thus be obtained on the same plate as, and in juxtaposition to, the photograph of the spectrum (as in Fig. E 1 A).

(*E 3*) Price, if ordered at the same time as the spectrograph ...

The accuracy with which wavelengths can be read on these scales is approximately as follows:—

Wavelength.	Error of Reading. (In Ångström units.)
7000	100
4000	20
3000	5
2500	2
2200	1

If desired, the scales can be divided to read frequencies instead of wavelengths, the price being the same.

(*E 5*) *Wavelength Scales* on glass for size E 2 similar to those described below in connection with size E 6. Price each ... ...

Quartz Spectrograph E 29.—Similar to quartz spectrograph E 2 (formerly known as size C) but of smaller aperture. Although this instrument requires approximately 50 per cent longer exposure than E 2, it is entirely suitable for the emission spectra of metals, and is of course less expensive. The prism is of the Cornu type, 27 mm. high, 40 mm. long face. The effective aperture of the lenses is 33 mm.
(*E 29*) Price ... ...

An internally mounted wavelength scale similar to E 3, as supplied with the quartz spectrograph E 2, can be supplied with quartz spectrograph E 29.
(*E 3*) Price ... ...

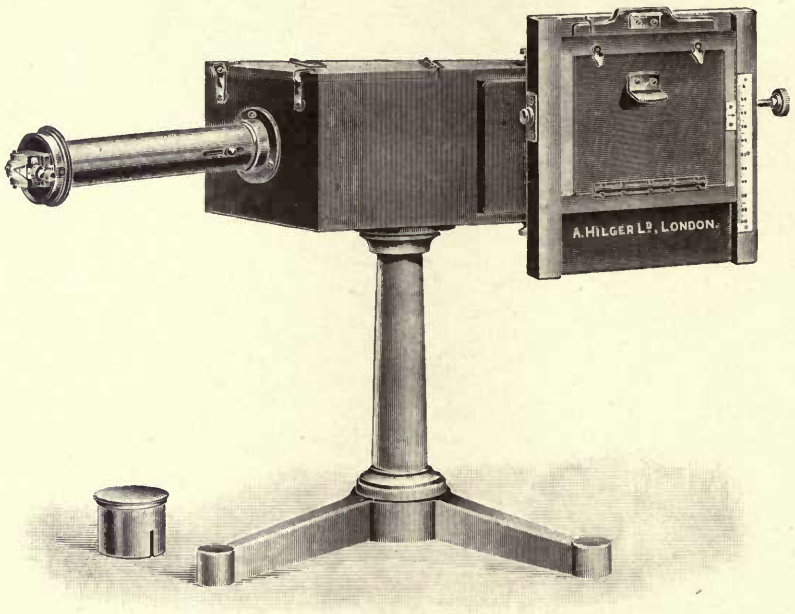

Fig. E 6.

Quartz Spectrograph, size E 6 (formerly known as size A).—Lenses of 8 inches (203 mm.) focus, the instrument (*see* Fig. E 6) giving a spectrum from 200 $\mu\mu$ to 800 $\mu\mu$ of about 65 mm. long. Size of plate, $4\frac{1}{4} \times 3\frac{1}{4}$ inches. The slit is our No. F 24 (*see* p. F 5). The dispersing system consists of one Cornu prism.
(*E 6*) Price ... ...

(Specimen photographs will be sent post free on application.)

Accurate scales of wavelengths have been prepared in connection with this spectrograph. These scales are photographed on glass, and can be laid direct on the spectrograms to read off the wavelengths. They are prepared to suit each individual instrument, and are sufficiently accurate to determine the identity of most lines.

(*E 7*) Price ... ...

The quartz spectrograph size E 6 can also be supplied, adjusted to take the whole spectrum from W.L. 1850 to W.L. 8000. Price, the same as the above.

CONCAVE GRATING SPECTROGRAPHS.

(EAGLE MOUNTING.)

(*See* Paper by A. Eagle "On a New Mounting for a Concave Grating")
Astrophys. Jour., *31*, page 120 (March 1910).

In comparison with the classical Rowland mounting, the Eagle mounting has the following advantages:—

(1) It occupies very little space.
(2) No darkened room is necessary.
(3) Spectra on either side of the normal may be used with equal facility; a point of some value, as it may happen that the best third-order spectrum is on the opposite side to the best first-order spectrum.
(4) Everything being on the same axis, great rigidity is obtained.
(5) It is much easier to ensure uniformity of temperature. This is of capital importance in making long exposures with the larger models.
(6) Higher orders are obtained.

Mr Eagle has developed in detail in the above-mentioned paper the comparison between the two methods of arranging the diffraction grating. We are of opinion that for the great majority of work the Eagle mounting is much to be preferred. We are, however, prepared to quote, if desired, for spectrographs constructed on the Rowland system.

SIZE E 14.

(*See* Fig. E 14.)

(*Suitable for a Grating of* 90 *c/m. radius and* 1·4″ *diameter;*
20,000 *lines per inch.*)

The instrument consists of a cast-iron girder on which are mounted the camera, and the slide for the grating carriage. The grating carriage is movable longitudinally by a screw of $\frac{1}{4}$″ pitch, the motion being sufficient to give the following ranges of spectra, if the grating be of 20,000 lines per inch.

1st order,	from	the extreme	violet to	1,900 $\mu\mu$
2nd	,,	,,	,,	950 ,,
3rd	,,	,,	,,	640 ,,
4th	,,	,,	,,	480 ,,
5th	,,	,,	,,	385 ,,

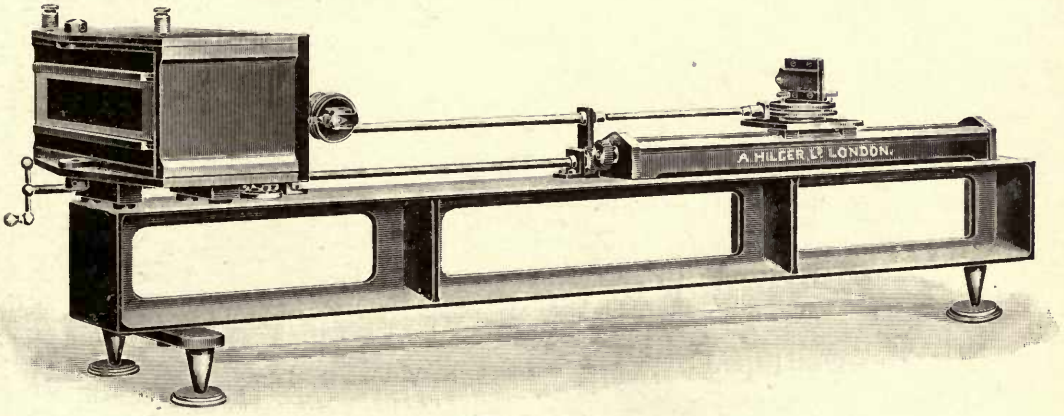

Fig. E 14.

The frame of the camera is of metal, the dark slide of mahogany. Comparison photographs are obtained by means of a sliding diaphragm in front of the plate actuated by screw motion. The slit is our No. F 24 size (*see* p. F 5). The size of the film is $10'' \times 2''$, of which $9\frac{1}{2}'' \times 1''$ are exposed.

We recommend that with this and the next size of instrument films be used. Stiff films are now easily obtainable from photographic plate makers (*see* p. F 12), and this will bend to the full curvature and give perfect definition from end to end. For the use of plates, however, a second dark slide is provided, which has only half the correct curvature, that being the greatest amount of bending to which one can safely submit even the specially thin plates now obtainable.

The grating mount is provided with means of levelling the grating, and of setting the lines of its ruling parallel to its axis of rotation. The slit can also be adjusted to be parallel to the lines of the grating. The instrument is provided with a well made light-tight cover.

(*E 14*) Price, including best quality Rowland grating of dimensions mentioned above ... ...

Rods from camera ends of the instrument to actuate the screw motion and rotate the grating; also counting mechanism to both for accurately setting the grating to any desired position.

(*E 15*) Price, extra ... ...

SIZE E 16.

(*Suitable for a Grating of* 120 *c/m radius and* 1·4″ *diameter.*)

This instrument is of the same design as size E 14, but of increased length.

(*E 16*) Price ... ...

The price of the rods and counters is the same as for the size E 14 instrument.

SIZE E 17.

(*Suitable for a Grating of* 305 *c/m radius and* 4″ *diameter.*)

With gratings of this radius it is usually preferable to mount the camera and the slides with screw motion, etc., on separate concrete or brickwork supports instead of both on one girder, and the camera and slides are designed for this purpose. A drawing of the necessary brickwork is sent in receipt of every order for one of these instruments. The wooden cover is provided as for the smaller size of grating mounting, but in this and in the following case a second inner cover is provided further to retard the temperature variations which with all large grating spectrographs are a source of great inconvenience if not provided against. The camera is arranged to take plates 40×4 c/m, and all

adjustments, as given under specification for size (*a*), are provided, together with rods from the camera to actuate the screw motion and rotation of the grating. The slit is our No. F 31 size (*see* pp F 5-6).

(*E 17*) Price, including best quality Rowland grating ... ...

SIZE E 18.

(*Suitable for a Grating of* 650 *c/m radius and* 6″ *diameter.*)

This size is of exactly the same design as size E 17 described above, with the exceptions that it is longer to suit the longer radius of curvature, and that the grating mount and carriage are suitably modified for the larger size grating.

(*E 18*) Price, including best quality Rowland grating ... ...

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March 1920.

SECTION F.*
ACCESSORIES FOR SPECTROMETERS AND SPECTROGRAPHS.

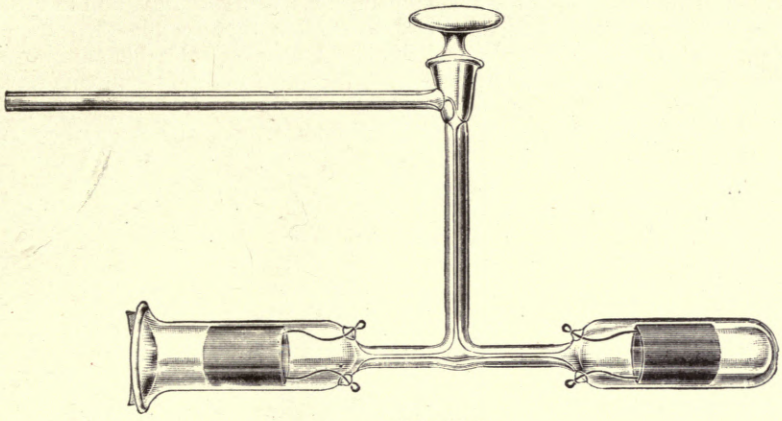


Fig. F 1.

Vacuum Tube for Experimental Work.—The tube is, as will be seen from the sketch (Fig. F 1), of the end-on type. It is supplied with a tap, and the light is concentrated into a line focus by a sphero-cylindrical condenser, of which the spherical portion fits accurately the ground and polished cup at the end of the vacuum tube.

(*F1*) Price, with glass condenser ...

(*F2*) Price, with quartz condenser ...

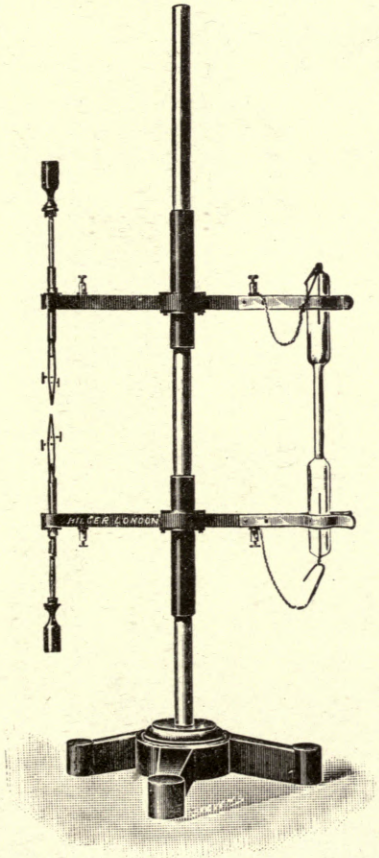


Fig. F 3.

Combined Vacuum Tube Holder and Spark Apparatus, readily interchangeable (Fig. F 3).

(*F3*) Price ... ...

Arc Lamp (Fig. F 4) suitable for the arc spectra of metals. Rods of the metal (of $\frac{1}{8}$ in. to $\frac{1}{4}$ in. diameter) are held in the spring clips. A direct current is employed, which should be off a circuit of 100 volts or more, with suitable resistance to give about 3 amps.

(*F4*) Price ... ...

Attachment for using the arc horizontal.

(*F5*) Extra ... ...

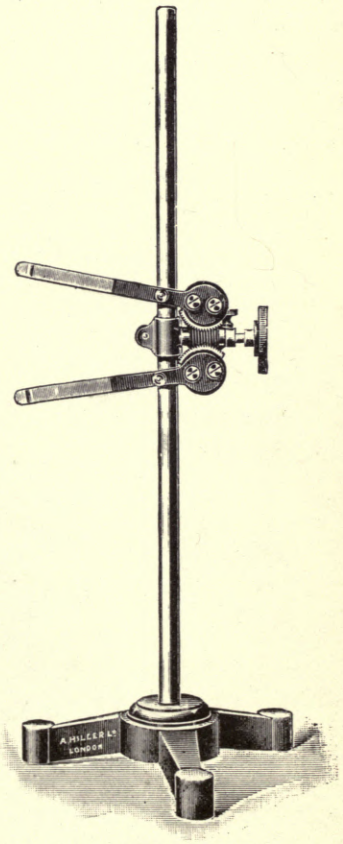


Fig. F 4.

Slit Rod for attachment to any Collimator.—This simple device can be quickly and easily attached to the collimator of any spectroscope without in any way interfering with the adjustments. The figures below show the slit rod in position clamped to a collimator, in Fig. F 6, F 10, a condensing lens being carried, and in Fig. F 6, F 12 a Baly adjustable absorption tube. The absorption tube, condenser, etc., are readily interchangeable and are adjustable for height. A very considerable gain in convenience results from being able to attach such accessories to the collimator in this way.

The following parts are supplied :—

Rod Carrier for attachment to any collimator tube, with rod and clamp for same.

(*F 6*) Price ... .

(*F 7*) Price, with two clamps, suitable for use with mirror and condenser simultaneously ... ...

(*F 8*) **Condensing Lens** of glass, with spherical surfaces in mount with stem for the above rod carrier. Price ... ...

(*F 9*) **Condensing Lens** of quartz, do., do. Price ... ...

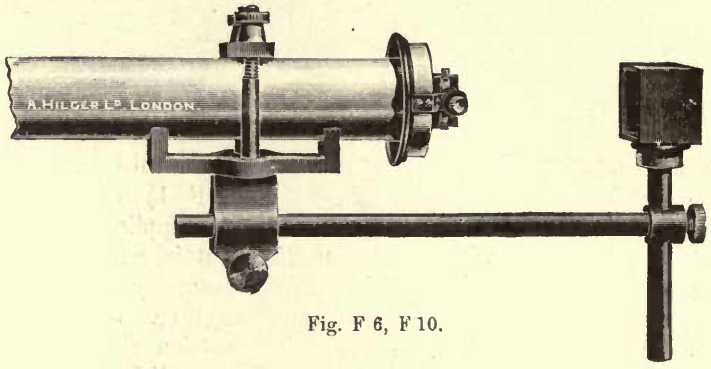


Fig. F 6, F 10.

(*F 10*) **Sphero-cylindrical Condenser** of glass (as in Fig. F 6, F 10) similarly mounted for the above rod carrier. Price ... ...

(*F 11*) **Sphero-cylindrical Condenser** of quartz. Price ... ...

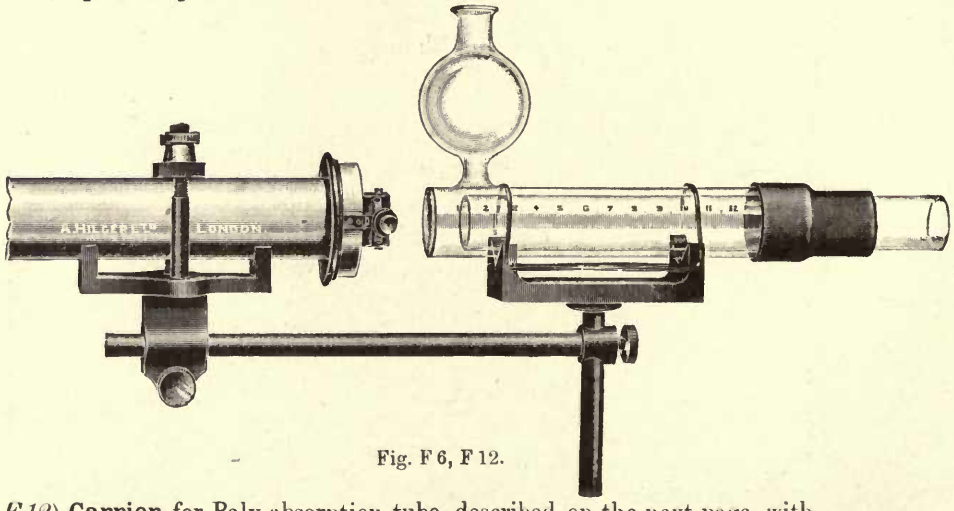


Fig. F 6, F 12.

(*F 12*) **Carrier** for Baly absorption tube, described on the next page, with stem for the above rod carrier (as in Fig. F 6, F 12). Price ...

(The absorption tube is held securely in place on its mount by means of a rubber band which passes under four projecting pins, the ends being looped over the tube.)

(*F 13*) **Mirror** in tilting mount, with stem for the above rod carrier. Price

Sphero-cylindrical condensers on raising and lowering stand, giving a line of light on the slit from a point source.

(*F 14*) Price, glass ... ...
(*F 15*) „ quartz ... ...

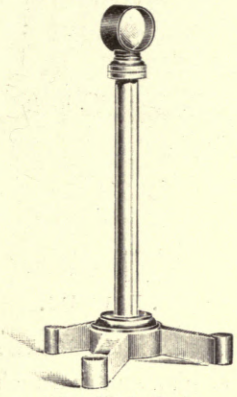


Fig. F 16, F 17.

Condenser (spherical surfaces) (Fig. F 16, F 17) on raising and lowering stand.

(*F 16*) Price, glass ... ...
(*F 17*) „ quartz ... ...

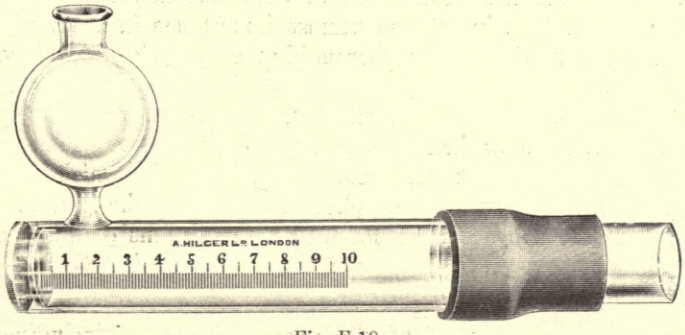


Fig. F 18.

Adjustable absorption tube for examination of the light absorption of liquids (*see* Baly's "Spectroscopy," First Edition, p. 414). The thickness of liquid can be read off on the scale in millimetres. With quartz end plates, 19 mm. clear aperture, as shown in Fig. F 18.

(*F 18*) Price ... ...

Engraved with logarithmic scale in addition to millimetre scale.

(*F 114*) Price, extra ... ...

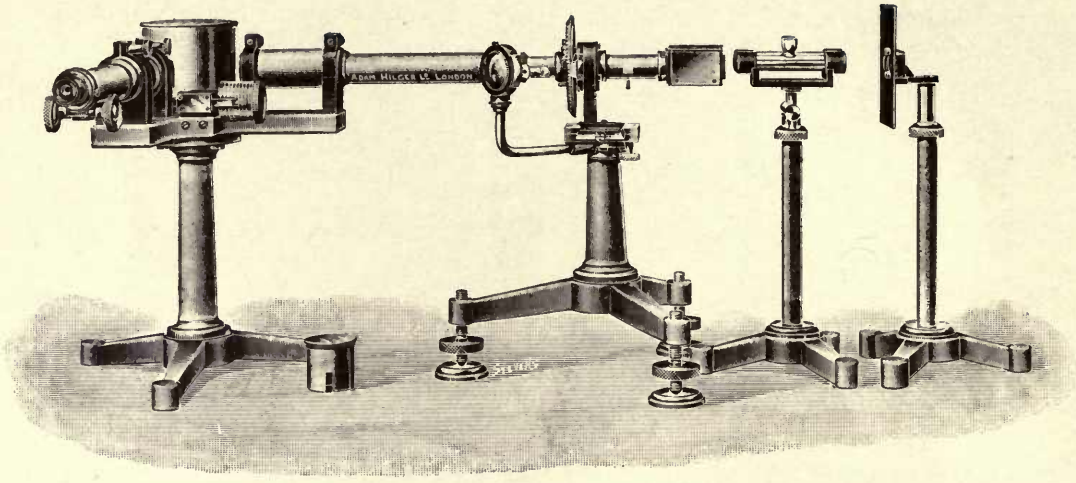


Fig. F 119, D 1.

NUTTING POLARISATION PHOTOMETER ATTACHMENT.

This is a form of polarisation photometer attachment for spectroscopes described by P. G. Nutting (*see* reprint No. 155, *Bulletin of the Bureau of Standards*), modified in one or two particulars. It can be used for all classes of spectrophotometry in the visible spectrum; and is supplied mounted on a tripod stand for use with any ordinary spectroscope.

The combination of the Nutting Photometer with a Hilger Wavelength Spectrometer results in a spectrophotometer which is accurate as regards both the wavelength and the photometric measurements, gives a great amount of light, and is extremely rapid to use. Great care has been taken to work out thoroughly the correct conditions of illumination (a point of the utmost importance in accurate spectrophotometry), and the instrument can be thoroughly recommended for all visual spectrophotometry.

The circle is divided both in "densities" and in degrees.

The prices given below include the supply of an arrangement on separate stand for producing two parallel beams of light, by which means, together with an adjustment provided on the photometer itself, the correct conditions of illumination referred to above can be obtained with columns of liquid of any desired length. The distance between the centres of the two beams is 38 mm. This arrangement is shown in Fig. F 119, D 1.

Nutting Photometer Attachment described above, and including small electric lamp for illumination of the scale.

(*F 119*) Price, on separate stand with levelling screws, suitable for use with any ordinary spectroscope ... ...

Raising and lowering stand for holding tubes of absorbing liquids, taking tubes 100 mm. long and upwards, or the Baly tubes described on p. F 3; with two carriers, each with stem, similar to the carrier for Baly tube on p. F 2, the correct beam distance apart for the Nutting Photometer.

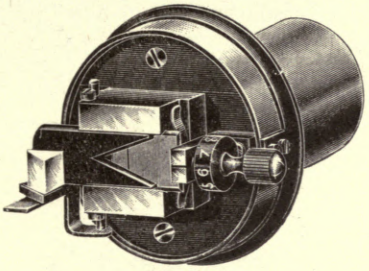
(*F 22*) Price ... ...

(*F 23*) 100 mm. tubes with screwed end caps, for the above, each ...

SPECTROSCOPIC ACCESSORIES.

SPECTROSCOPE SLITS.

Note.—All Spectroscope Slits made by us have jaws of untarnishable metal.



0·6 × *actual size.*

Fig. F 24.

Slit (Fig F 24) with fine screw adjustment; having divided drumhead, comparison prism, wedge for reducing the aperture, screws for correcting want of parallelism of the jaws, should this become at any time necessary, and protective cap.

(*F 24*) Price ... ...

Instead of the wedge a sliding diaphragm with three apertures for spectrum photography, giving the spectra in close juxtaposition, can be supplied with this slit.

(*F 25*) Price, extra, if supplied instead of wedge ... ...

(*F 26*) „ „ in addition to „ ... ...

(*F 27*) Price of slit No. F 24, opening symmetrically (without wedge or diaphragm) ... ...

Maximum length of slit which can be utilised in either of the above = 7 mm.

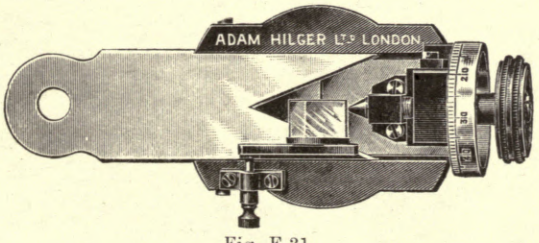
The above slits can also be supplied giving a length of slit = 14 mm. (without reducing wedge) as follows :—

(*F 28*) Ordinary form ... ...

(*F 29*) Opening symmetrically ... ...

(*F 30*) Glass window to protective cap in any of the above, extra ...

The wedges and sliding diaphragms for reducing the aperture, and the screws for correcting the parallelism of the jaws are not supplied on the above symmetrical slits.



0·6 × *actual size.*

Fig. F 31.

Slit (Fig. F 31), with adjustment by fine steel micrometer screw, and large divided drumhead, comparison prism, wedge for reducing the aperture, and screws

for correcting want of parallelism of the jaws. (Maximum length of slit which can be utilised = 18 mm.)

(*F 31*) Price ... ...

Instead of the wedge a sliding diaphragm with three apertures for spectrum photography giving three comparison spectra in close juxtaposition can be supplied with this slit.

(*F 32*) Price, extra, if supplied instead of the wedge ... ...

(*F 33*) „ „ in addition to „ ... ...

(*F 34*) Morocco case for No. F 31 ... ...

CROSSED SLITS.

For many purposes it is desirable to have two slits superposed at right angles, both adjustable (*see*, for instance, our Wavelength Spectrometer modified for use with high resolving power accessories, Section O, for one use of such slits). We make these in two sizes.

(*F 35*) Main slit of the same size as slit No. F 24.

Price ... ...

(*F 36*) Main slit of the same size as slit No. F 31.

Price ... ...

In both the above the secondary slits can be readily rotated out of the field, or entirely removed if desired. No comparison prism or wedge is supplied in either case.

EYEPIECES, ETC.

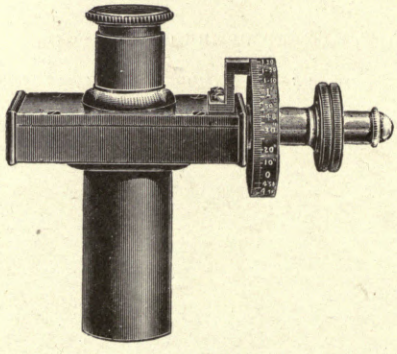


Fig. F 39.

Micrometer Eyepiece, pitch of screw = ½ mm.

(*F 39*) Price ... ...

Shutter Eyepiece (Fig. F 40), including one positive eyepiece, bright pointer with lateral adjustment and mirror with universal motion for illumination of the same to render it visible in a dark field, and two sliding shutters in the focal plane.

(*F 40*) Price ... ...

Note.—This eyepiece has two shutters, which can be shifted in from either side at will in the focal plane to cover any desired part of the field, thereby obscuring any bright spectral lines which by their proximity hinder the observation of feebler lines. The metal pointer, whose point is ground exceedingly fine and polished bright with the greatest care, is illuminated from above by a mirror. This bright pointer is adjustable laterally by the two milled head screws below, so that one can always return to the standard reading by setting the bright pointer on a reference line.

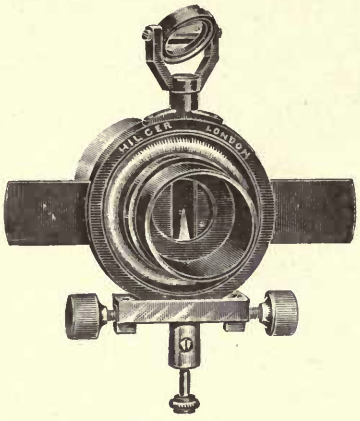


Fig. F 40.

(*F 41*) Slide with light filters to the shutter eyepiece for giving the pointer any desired colour, by means of which an increase of accuracy and comfort in reading can be secured—especially in the violet part of the spectrum ... ...

Fluorescent Eyepiece, as designed by Prof. Liveing for visual work in the ultra-violet.

(*F 43*) Price ... ...

Illumination of the pointer in above by mirror with universal motion.

(*F 44*) Price (extra) ... ...

Gauss Eyepieces.—This is a positive, or Ramsden, eyepiece with a plane glass inclined at 45° to the optical axis, placed between the two lenses. Light entering through an aperture in the side of the tube is thrown by the mirror on to the webs. A clear space is left in the middle of the mirror through which the webs can be observed. This forms a very useful accessory to a spectrometer for the accurate adjustment of the optical axis, etc.

(*F 45*) Price ... ...

Autocollimating Eyepiece, having slit with adjusting screw with divided drumhead (the jaws being in the focal plane of the eyepiece), and reflecting prism.

(*F 46*) Price ... ...

VACUUM TUBES, Etc.

(Best quality only stocked.)

Tubes of Hydrogen or other common gases.

(*F47*) Price, each, ordinary form .. ..

Mercury Tubes.

(*F48*) Price, each, ordinary form ... ...

"End-on" Tubes can be supplied if desired.

(*F49*) Price, each, hydrogen or other common gases ... ...

(*F50*) Price, each, mercury or cadmium ... ...

Vacuum Tubes of ARGON, HELIUM, NEON, KRYPTON, XENON.

(*F51*) Vacuum Tubes of Krypton or Xenon of guaranteed purity.

(*F52*) Vacuum Tubes of Neon, Helium, or Argon of guaranteed purity.

(*F53*) Vacuum Tubes of Helium or Argon, good tubes, but purity not guaranteed.

Vacuum Tubes of FUSED SILICA, for Ultra-Violet Work, with secure mercury seals.

	Ordinary Form.	End-on Form.
(*F54*) Filled with Hydrogen, Oxygen, Nitrogen, etc.		(*F58*)
(*F55*) Filled with Helium, Argon, or Neon of guaranteed purity.		(*F59*)
(*F56*) Filled with Krypton or Xenon of guaranteed purity		(*F60*)
(*F57*) Unfilled, with tube for exhaust, for experimental purposes.		(*F61*)

Vacuum Tubes of FUSED SILICA, with External Electrodes.

(*Prints of vacuum tube spectra taken with these tubes will be sent on request.*)

Although these tubes do not give so brilliant a discharge as the usual form, they have the advantage of absolute permanence.

(*F62*) Price, unsealed, for experimental purposes, with tube for exhaust ...

(*F63*) Price, with Hydrogen, Oxygen, Nitrogen, or other common gas ...

(*F64*) Price, with Helium, Argon, or Neon of guaranteed purity ... ...

(*F65*) Price, with Krypton or Xenon of guaranteed purity ... ...

Sparking Tubes with gold electrodes and platinum conducting wires for the spark spectra of metals in solutions (as used by Dr James H. Pollok in his researches on the quantitative spectra of metals in solution ; *see* Sci. Proc. Royal Dublin Society, vol. xi., Nos. 16, 17, 18).

(*F66*) Price, each ... ...

PLANO-CONVEX LENSES OF QUARTZ (SECOND QUALITY), SUITABLE FOR CONDENSING LENSES.

	Diameter.		*Focal Length.*		*Price.*
	in.	mm	in.	mm.	
(*F68*)	1	25·4	3	76	
(*F69*)	$1\frac{1}{4}$	32	$3\frac{3}{4}$	95	
(*F70*)	$1\frac{1}{2}$	38	$4\frac{1}{2}$	114	
(*F71*)	$1\frac{3}{4}$	44	$5\frac{1}{4}$	133	
(*F72*)	2	51	6	152	
(*F73*)	$2\frac{1}{4}$	57	$6\frac{3}{4}$	174	

HILGER THERMOPILES.

(LINEAR THERMOPILES OF GREAT SENSITIVENESS.)

The Design for this Thermopile is registered in the United Kingdom, and is protected by Design Patents in France, Germany, and U.S.A.

THE following thermopiles are the result of experiments in our laboratories, undertaken with a view to putting on the market a thermopile of great sensitiveness for spectrum work. Our experiments during 1912 convinced us of the soundness of the principles of construction laid down by Johansen in his very valuable paper in the *Annalen der Physik* (4), **33**, p. 517, 1910, and it is on the general principles enunciated in that paper that our thermopiles are constructed. The distinctive design is our own.

We supplemented the work of Johansen by experiments in our own laboratory on the distribution by convection, conduction, and radiation of the energy received by the thermopile; and from the data thus obtained we were able to calculate very closely for each size of thermopile the number of elements, dimensions of lead wires, etc., to produce the maximum sensitiveness. It should be noted that there is in each case a particular number of elements giving maximum sensitiveness, and thermopiles having more than this number are *less* sensitive.

To obtain greatest sensitiveness the galvanometer should have a resistance not greatly different from that of the thermopile.

The couple chosen was Bismuth-Silver, a combination which produces a thermopile superior in sensitiveness to any other couple which had been tried for this purpose, with the exception of Bismuth-Iron.[1] Although the latter is somewhat more sensitive, the iron is very subject under ordinary working conditions to rust, which may render the thermopile useless in a few weeks. The receiving plates are of silver foil.

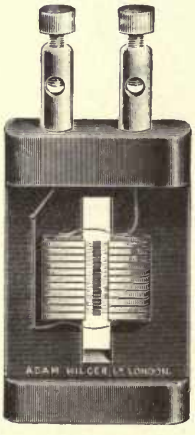


Fig. F 86.

Our more recent experiments, however, have resulted in a still further improved design, which, while having a sensitiveness nearly 50 per cent. greater than our previous model, is almost entirely free from "creep." It is thus much better adapted for use with very sensitive galvanometers for energy measurements in the ultra-violet, etc. In this improved form the Hutchins alloys are used (bismuth-tin and bismuth-antimony).

The thermopile for use in air is shown in Fig. F 86. It can be supplied either in a simple mount or in a symmetrical slit.

The simple mount (Fig. F 83) has a tube with eyepiece and a protecting tube which can be screwed on over this eyepiece tube without disarranging the eyepiece. It also has a tube with the standard fitting for the telescopes of our spectrometers.

[1] A further exception is Bismuth-Tellurium. We have made thermopiles of Bismuth-Tellurium, a couple which gives, for equal rise of temperature, an E.M.F. about eight times as great as Bismuth-Silver; but have not yet been able to produce them of sufficient permanence, mechanical soundness, or rapidity of action to justify our placing them on the market.

The symmetrical slit mount is also provided with these same tubes.

Both the above mounts are arranged for attachment to a raising and lowering stand.

The following Thermopile, designed for use in air, can usually be delivered from stock :—

Dimensions of sensitive area—20 mm. long; 1·5 mm. wide.
Number of junctions—20.
Resistance (approximate)—10 ohms.

(*F 83*) Price of the thermopile described above, mounted in simple mount
(*F 84*) ,, ,, ,, symmetrical slit
(*F 85*) Raising and lowering stand to take either of the above, extra ...
(*F 86*) Sensitive portion of above thermopile alone, in brass case ... ...

We can also supply thermopiles having sensitive areas as follows :—

Length.	*Width.*	*In Simple Mount.*	*In Symmetrical Slit.*	*In Brass Case.*
10 mm.	1 mm.	(*F 87*)	(*F 89*)	(*F 109*)
10 mm.	0·5 mm.	(*F 88*)	(*F 90*)	(*F 110*)

which are interchangeable in the mounts described above, at the same prices. We can further supply thermopiles designed to have maximum sensitiveness when used in vacuo.

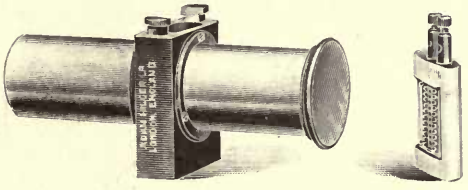


Fig. F 83.

Broca Galvanometer (made by the Scientific Instrument Co., Cambridge), selected as being suitable for general work with the thermopile.

(*F 91*) Price ... ...

Paschen Galvanometer (made by the Scientific Instrument Co., Cambridge).—This is a modified form of the Thomson Galvanometer, and was specially designed by Professor Paschen for radiometric measurements. The magnet system consists of two groups of thirteen magnets arranged alternately on opposite sides of a fine glass stem. The coils are elliptical in shape, and are wound with six different sizes of wire, with the object of producing a maximum field for a given resistance of copper. The sensitivity is about forty times as great as that of the Broca Galvanometer. The period can be varied by means of a control magnet.

(*F 92*) Price of the galvanometer having a resistance of about 12 ohms.

(*F 93*) Scale, on stand, with lamp for use with the above galvanometers.
Price ... ...

SENSITIVE PLATES FOR SPECTROGRAPHIC WORK.

THE following plates, manufactured by Messrs KODAK, Ltd., are those which we have found the best fo general Spectrographic work. The sizes indicated by larger type are those which are used for all ou stock Spectrographs, and may be had by return of post.

PANCHROMATIC "A" . .	Sensitive from the Ultra-violet up to 6800 Å.U.
PANCHROMATIC "B" . .	Rather less green sensitive than Panchromatic "A," but sensitive to about 7800 Å.U.
WRATTEN "M" . . .	Of similar sensitiveness to Panchromatic "A," but of much fine grain and about one-third the speed.
ALLOCHROME . . .	Evenly sensitive to about 5600 Å.U.
DOUBLE INSTANTANEOUS .	A fast "ordinary" plate of fine grain suitable for Ultra-violet work.

Not only are these plates extremely sensitive, but they keep good for a long time.

SIZE.	PRICE PER DOZEN.		SIZE.	PRICE PER DOZEN.	
Inches.	Panchromatic A or B, or M.	Allochrome or D. Instant.	Centimetres.	Panchromatic A or B, or M.	Allochrome or D. Instant.
$4\frac{1}{4} \times 1$			2·5 × 10		
$4\frac{1}{4} \times 3\frac{1}{4}$			3 × 9		
$6\frac{1}{2} \times 1\frac{1}{2}$			6 × 9		
$6\frac{1}{2} \times 2$			6·5 × 9		
$6\frac{1}{2} \times 2\frac{3}{8}$			4·3 × 18		
$6\frac{1}{2} \times 4\frac{3}{4}$			9 × 12		
$9\frac{3}{4} \times 4\frac{1}{4}$			*4 × 24		
***10 × 2**			*4 × 30		
***10 × 4**			*6 × 24		
*12 × 2			13 × 18		
*12 × $2\frac{1}{2}$			5·5 × 50		
12 × 3					

Other sizes at corresponding prices.

* We can supply plates of these sizes coated on extra thin glass to bend to a radius of about 30 inches (75 centimetres) a an increase of 25 per cent. on the above prices. For greater curvature than this we recommend the use of celluloid film This (about 0·5 mm. in thickness) can be made to order at an advance of 50 per cent. on plate prices. All plates ma be had backed at a slight extra charge.

Messrs KODAK, Ltd., also make LIGHT FILTERS, of which upwards of eighty varieties are no stocked, either transmitting narrow bands, or cutting out a specified region of the spectrum. Pric Lists on application.

Photographic Plates for the Region in the Ultra-Violet between Wavelength 220 $\mu\mu$ and 90 $\mu\mu$, for Positive Rays, and for the very soft Röntgen Rays produced by the Impact of Positive and Slow Cathode Rays (*see* paper by Sir J. J. Thomson, Proc. Phys. Soc., vol. xxvi., Part V., Aug. 1914, p. 388).

The strong absorption of light by gelatine renders the ordinary photographic plate of little value beyond wavelength 210 $\mu\mu$, in fact the general absorption by gelatine extends almost up to the visible region of the spectrum. The first plates used for the extreme ultra-violet were prepared by Schumann,[1] the gelatine being reduced to the minimum necessary to hold the silver bromide on the plate.

We can now supply plates made to a modification of the Schumann formula and suitable for the purposes mentioned above at the following prices :—

	Size. Inches.	Cms.	Price per dozen.
(*F 94*)	$4\frac{1}{4} \times 3\frac{1}{4}$	10·8 × 8·2	
(*F 95*)	10 × 4	25·4 × 10·2	

Other sizes can be supplied, providing that not less than three dozen are ordered, the price in shillings per dozen being determined by the formula 9·5 + 2·1 × area in inches.

The advantage of these plates becomes very apparent after wavelength 220 $\mu\mu$, and at wavelength 185 $\mu\mu$ they are five times as rapid as the most sensitive commercial plates, while for shorter wavelengths the latter are of course of no use at all.

These plates will stand handling much better than those made to the original Schumann formula. They increase in sensitiveness for some time after being made, and providing they are kept with the customary care, they have a life of similar length to that of the ordinary dry plate.

Plates for the Extreme Red.—For the extreme red we have found the Ilford Special Red Sensitive Plates excellent. They are sensitive to 800 $\mu\mu$, and can be supplied at the following prices :—

	Size Inches.	Price per dozen.		Size Inches.	Price per dozen.
(*F 96*)	$4\frac{1}{4} \times 1$		(*F 102*)	$9\frac{3}{4} \times 4\frac{1}{4}$	
(*F 97*)	$4\frac{1}{4} \times 3\frac{1}{4}$		(*F 103*)	10 × 2	
(*F 98*)	$6\frac{1}{2} \times 1\frac{1}{2}$		(*F 104*)	10 × 4	
(*F 99*)	$6\frac{1}{2} \times 2$		(*F 105*)	12 × 2	
(*F 100*)	$6\frac{1}{2} \times 2\frac{3}{8}$		(*F 106*)	12 × $2\frac{1}{2}$	
(*F 101*)	$6\frac{1}{2} \times 4\frac{3}{4}$		(*F 107*)	12 × 3	

We can supply plates of these sizes coated on extra thin glass to bend to a radius of about 30″ (75 centimetres) at an increase of 25 per cent. on the above prices. For greater curvature than this we recommend the use of celluloid film. This (about 0·5 mm. in thickness) can be made to order at an advance of 50 per cent. on plate prices. All plates may be had backed at a slight extra charge.

Ilford Special Red Sensitive Plates on extra thin glass above 10″ long can only be supplied specially to order, and from two to three weeks will be required for delivery. Orders cannot be accepted for less than one dozen, and the makers are to be allowed to send any "overs" that it may be found necessary to prepare in executing orders.

No films can be supplied more than 10″ long or 8″ wide, and they are not quite so highly red sensitive as the plates.

[1] Ann. der Physik, 5, 349 (1901).

Index of Spectra, by W. MARSHALL WATTS, D.Sc. (Lond.), B.Sc. (Vict.), F.I.C. Revised Edition, greatly enlarged. Will be sent post free at the following price:—Bound volume, including Appendix A, £1, 5s. (Specially recommended.)

And the following Appendices, in paper covers:—

Appendix B (Table of corrections to reduce to Rowland's Standard, ultra-violet Spectra of Co and Ni, etc.), 3s. 6d.

Appendix C (Spectrum of Iron, telluric lines of solar spectrum, spectrum of Hydrogen), 7s. 6d.

Appendix D (Arc-spectra of Ga, Li, Na, K, Rb, Cs, Mg, Ca, Zn, Sr, Cd, Ba, Hg, absorption spectrum of Bromine, Arc-spectrum of Alumina), 5s. 6d.

Appendix E (Spectra of Air, Cu, Ag, Au, Al, In, Tl, C, CN, N, Si, Ammonia, and the Table of reductions to vacuum), 4s. 6d.

Appendix F (The Arc-spectra of Cr, Sn, Pb, Sb, Bi, flame-spectra of K, Na, Li, Ca, Sr, Ba, etc.), 3s. 6d.

Appendix G (Rowland's Standard Wavelengths, Spectra of Hg, He, Cd, etc., and oxyhydrogen spectra), 5s. 6d.

Appendix H (The three spectra of Argon, the arc-spectrum of Ti, the spark-spectra of Cu, Ag, and Au), 5s. 6d.

Appendix I (The arc- and spark-spectra of Co and Ni, and "Index Indicis"), 5s.

Appendix J (The spark-spectra of Fe and W, and the arc- and spark-spectra of Pt), 8s.

Appendix K (Spectrum of Chlorine, and the spark-spectrum of Mo), 5s.

Appendix L (Spectra of Bromine, Gallium and Radium, and the spark-spectrum of Uranium), 7s. 6d.

Appendix M (The arc-spectra of Mn and V, the spark-spectra of V, Au and Si, and the spectrum of Argon), 6s.

Appendix N (Flame-spectrum of Radium, infra-red spectra of Alkalies, ultra-violet spectrum of Thorium), 4s.

Appendix O (Arc-spectrum of Mo, spark-spectra of Ca, Sc, In, Be, Li, Tl, K, Cs, Sb, As, Ra), 4s.

ADAM HILGER, Ltd., 75a Camden Road, London, N.W. 1

Appendix P (Arc- and spark-spectra of Ruthenium, Yttrium: Line- and Band-spectra of Sulphur), 7s. 6d.

Appendix Q (Spectra of Neon, Xenon, and Krypton; and a second "Index Indicis"), 4s. 6d.

Appendix R (Spark-spectrum of Cr, arc- and spark-spectra of Pa, and the spectra of Polonium and Ex-radio), 5s. 6d.

Appendix S (Arc- and spark-spectra of Ir, Os, and Rh), 10s. 6d.

Appendix T (Arc- and spark-spectra of Tantalum, Zirconium, and Lanthanum), 8s.

Appendix U (Table of Stronger Lines of the Elements, arranged according to Wavelength), 10s. 6d.

Appendix V (Price 12s. 6d.) contains Air, Aldebaranium, Aluminium, Alumina, Ammonia, Antimony, Argon, Arsenic, Barium, Beryllium, Bismuth, Boron, Bromine, Cadmium, Cæsium, Calcium, Carbon, Cassiopeium, Cerium, Chlorine.

Appendix W, the *second* of a *series* (V, W, etc.), intended to complete and bring up to date the Index of Spectra and previous Appendices, containing Chromium, Cobalt, Copper, Dysprosium, Erbium, Europium, Fluorine, and "Additions and Corrections to Appendix V."

Appendix X, *third* and *last* of the *series*, contains Gadolinium, Gallium, Germanium, Gold, Helium, Holmium, Hydrogen, Indium, and "Additions and Corrections to Appendices V and W."

Note.—(Specially recommended).—Appendices B to I inclusive are also supplied bound in one volume, £2, 3s.

Appendices J to Q inclusive, bound in one volume, £2, 8s.

(*This work can now only be supplied in sets comprising either the three bound volumes or the three bound volumes with Appendices R to X.*)

ADAM HILGER, Ltd., 75a Camden Road, London, N.W. 1

Telegraphic Address—"Sphericity, Phone, London."
Telephone—North 1677/8.
Cable Code—Western Union.

March 1920.

SECTION G.*

SOLAR AND STELLAR SPECTROSCOPES.

STELLAR SPECTROSCOPES.

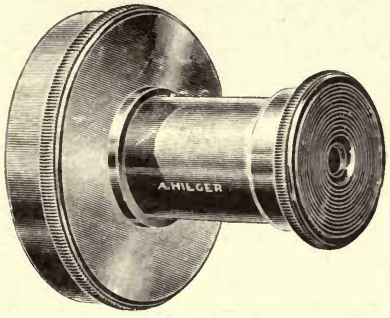


Fig. G 1.

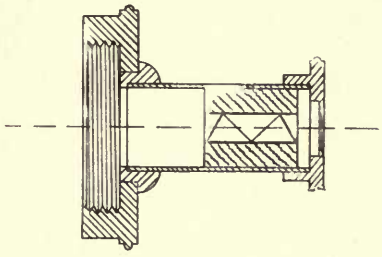


Fig. G 1 A.

Zöllner Star Spectroscope (Figs. G 1 and G 1 A). *See* article in "Knowledge," by Prof. A. Fowler, F.R.A.S., April 1903. The series of six articles on "The Chemistry of the Stars," of which this is one, appeared in February, April, June, August, October, and December 1903, and should be consulted by all those intending to take up Stellar Spectroscopy. In the second of these articles will be found a description of actual work done with a Zöllner Spectroscope on a 3-inch telescope.

The use of the Zöllner Star Spectroscope is extremely simple. It is screwed or fitted on to any eyepiece, and is thus situated, when in use, between the eye and the eye-lens of the eyepiece.

A low-power eyepiece should be selected, one as low as 10 per inch of the object glass diameter may be used with advantage; thus with a 3-inch diameter object glass a power of 30 would not be too low.

(1) The star should be focussed with the eyepiece to be used, and guided into the centre of the field.

(2) The Zöllner Star Spectroscope should then be screwed on, care being taken not to move the telescope.

The spectrum of the star can then be seen, and the cylinder lens cap chosen according to the width of the band desired and the brightness of the star.

Note.—In the use of this spectroscope observers are often troubled by indistinct lines or shadows running along the spectrum. These are present in all similar forms of star spectroscope to a greater or less degree. They are produced by dust on the prism of the Zöllner Star Spectroscope, in the eyepiece used, or on the cylinder lens of the cap, and also by imperfections of the lens of the eye.

They can be partially obviated by cleaning the various lenses, but they can never be entirely got rid of, and do not interfere with the efficient working of the instrument.

(*G 1*) Price, with one cylinder lens cap and compound prism, adapted to any eyepiece ... ...

Do. with three different powers of cylinder lenses, in morocco case.

(*G 2*) Price ... ...

An order for a Zöllner Star Spectroscope should always be accompanied by the eyepiece to which the Spectroscope is to be adapted.

Note.—The Zöllner Star Spectroscope can also be used to test the achromatism of Object Glasses of Telescopes.

Small Direct Vision Spectroscope, with adjustable slit, compound prism, cylinder lens, and tube for adaptation to any telescope; or, if preferred, with astronomical thread (suitable for nebulæ or aurora spectrum).

(*G 3*) Price ... ...

Objective or Disc Prisms for adaptation in front of Astronomical Object Glasses for Stellar Spectroscopy, of Guaranteed Quality.

Refractive index for D = 1·57 to 1·62.

10° Refracting Angle.				40° Refracting Angle.			
Clear effective aperture.			Price.	Clear effective aperture.			Price.
	in.	mm.			in.	mm.	
(*G 4*)	2½	63		(*G 10*)	2½	63	
(*G 5*)	3	76		(*G 11*)	3	76	
(*G 6*)	4	102		(*G 12*)	4	102	
(*G 7*)	5	127		(*G 13*)	5	127	
(*G 8*)	6	153		(*G 14*)	6	153	
(*G 9*)	8	203		(*G 15*)	8	203	

The faces of the above prisms are elliptical, giving a circular effective beam of light of the diameter stated.

The above prices do not include cells or mounting. Larger sizes quoted for on application.

Note.—*Stellar Spectrographs of any size designed according to requirements.*

SOLAR SPECTROSCOPES.

Small Prominence Spectroscope, being a **Direct Vision Spectroscope** with diffraction grating, No. J 15 (*see* list of Direct Vision Spectroscopes, Section J), adapted to customer's own telescope for use as a small solar spectroscope. (*See* paper on "Solar Spectroscopy with Simple Instruments," by W. Alfred Parr, *Jour. B. A. A.*, vol. xix., 30th July 1909, p. 395.)

With this instrument solar prominences can be seen.

A telescope for addition to the above can be supplied for observation of the C line, and with the instrument thus arranged the prominences become more easily observable. Bright reversals of the C line can also frequently be seen.

Mounted on tube, or astronomical thread for adaptation to customer's own instruments.

Orders should preferably be accompanied by the draw tube from the telescope to which the spectroscope is to be adapted ; or failing that, by an eyepiece which fits the same.

(*G 18*) Price without auxiliary telescope, but including adaptation to customer's telescope ... ...

(*G 19*) Price with small auxiliary telescope for special observation of C line ... ...

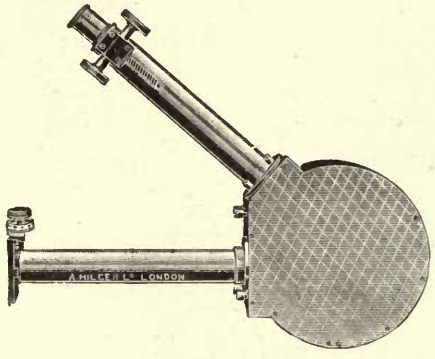


Fig. G 20.

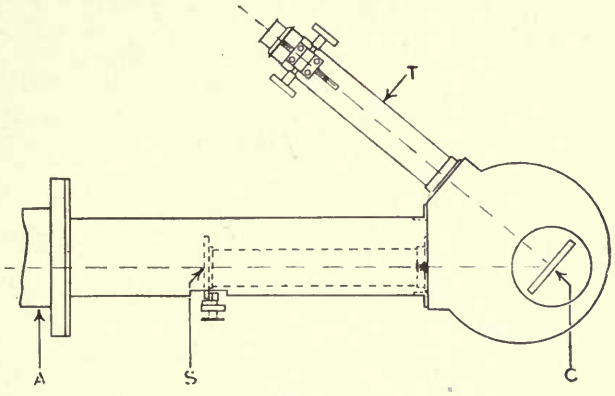


Fig. G 20 A.

Orders for the three following Solar Spectroscopes should be accompanied by—

(1) A note of the distance from the solar image to the end of the telescope tube to which it is proposed to adapt the spectroscope when the telescope tube is in the middle of its range of movement.

(2) The draw tube of the telescope or, alternatively, a tube into which the draw tube has been carefully fitted so as to form a gauge for us to reproduce it. It is also necessary to send the measurement from the end of the draw tube to the solar image when the telescope rack work is in the middle of its motion.

(3) The focal length of the telescope to which the spectroscope is to be adapted.

Grating Spectroscope for Observation of the Solar Prominences.— The above instrument (Figs. G 20 and G 20 A), while not so powerful as the Evershed Solar Spectroscope, still shows the prominences admirably, and makes an excellent spectroscope for all kinds of solar work.

It consists of an adapter tube A, which is made to fit the telescope to which it is intended to adapt the spectroscope. To this the instrument is adapted by means of a substantial fitting, which enables the spectroscope to be rotated about the axis of the telescope to which it is attached.

The slit S is set eccentric by an amount equal to half the diameter of the solar image, so that on rotation the slit passes tangentially round the circumference of the sun. The slit is of best quality, with steel screw, drumhead divided into 100 divisions, and non-corrosive jaws.

The collimator and telescope are of 6½-inch focal length (152 mm.).

The box which contains the grating and which constitutes the frame of the instrument is of carefully selected aluminium alloy.

The telescope T has rack and pinion focussing.

The grating G supplied is a selected film replica of a Rowland best quality grating. Or, if desired, the instrument can be supplied with a Rowland best quality metal reflecting diffraction grating (lines per inch, 14,438). In either case the grating has rack and pinion motion for passing through the spectrum. (The slit is the same as that shown in Fig. G 24 B.)

(*G 20*) Price, with best selected film replica grating ... ...

(*G 21*) Do., with Rowland best quality metal diffraction grating ...

A small extra charge is made for adapting the above to the telescope.

Curved slit permitting a larger section of the solar circumference to be observed at one time.

(*G 22*) Price, extra ... ...

(*G 23*) Case for the above instrument ... ...

EVERSHED SOLAR SPECTROSCOPES.

Designed by J. Evershed, F.R.A.S., for Solar work, and especially for the observation of Solar Protuberances.

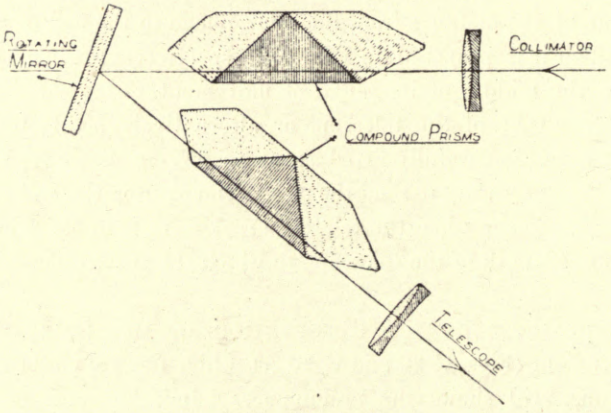


Fig. G 24 A.

By means of a special arrangement of prisms and a rotating mirror (*see* Fig. G 24 A), a very light and compact form of spectroscope has been produced, which is, at the same time, exceedingly powerful; the dispersion between the A and H Fraunhofer lines being 60° for the 2 prism, and 90° for the 3 prism instruments.

The designs of the optical arrangements in the two instruments described below are the result of Mr Evershed's wide experience in this class of work, and the form of mounting has been adopted, as best suited to the purpose. The instrument comprises

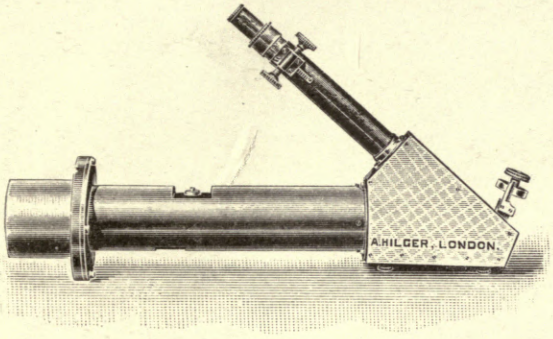


Fig. G 24.

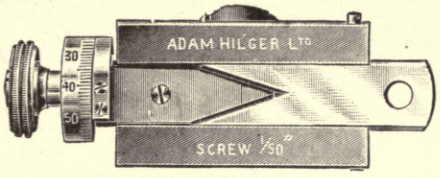


Fig. G 24 B.

EVERSHED PROTUBERANCE SPECTROSCOPE, 2 PRISM PATTERN

(Fig. G 24).

two compound prisms, each of extremely high dispersion, rotating mirror actuated by steel micrometer screw, by means of which accurate wavelength measurements can be made; best quality slit with steel screw, drumhead divided into 100 divisions, and untarnishable jaws. The frame is of a carefully selected aluminium alloys, making the instrument exceedingly light. High- and low-power eyepieces with cross webs are supplied, and the telescope has rack and pinion focussing. Means of rotation are provided with a division for observation of the various parts of the solar circumference. The slit is shown in Fig. G 24 B.

(*G 24*) Price ... ...

A small extra charge is made for adapting the above to the telescope.

Curved slit, permitting a larger section of the solar circumference to be observed at once; made exact to any required solar image, and interchangeable with the ordinary slit.

In ordering a curved slit the exact diameter of the solar image should be given.

(*G 25*) Price ... ...

The above instrument can be supplied with rack and pinion motion for passing through the spectrum instead of micrometer screw.

(*G 26*) Price ... ...
(*G 27*) Curved slit ... ...
(*G 28*) Case for above instrument ... ...

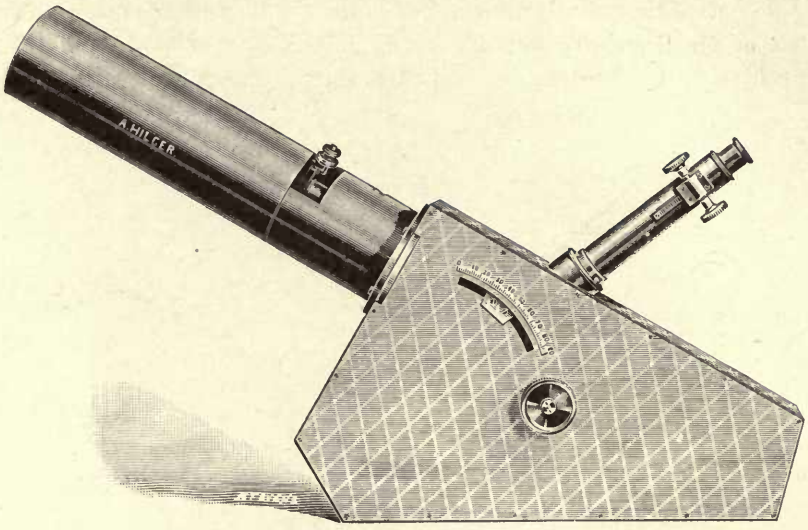


Fig. G 29.

EVERSHED PROTUBERANCE SPECTROSCOPE, 3 PRISM PATTERN (Fig. G 29).

Comprises three compound prisms similar to those in the two prism form ; two mirrors, simultaneously rotated by rack and pinion motion, vernier for reading off the position in the spectrum ; otherwise answering to specification of the two prism instrument.

(*G 29*) Price ... ...

(*G 30*) Curved slit (extra) ... ...

(*G 31*) Case for above instrument ... ...

Littrow Spectrograph, with 10 ft. focus achromatic object glass and best quality 4 in. Rowland Diffraction grating.

(*G 41*) Price ... ...

This form of spectrograph has also been extensively used with a dispersing system consisting of one 60° and one 30° prism, from the second face of which the light is reflected back, giving a dispersion equal to that of three 60° prisms. This latter form is preferable to that with the grating in point of view of light-giving power, and it is to this form that the name of "Littrow" Spectrograph properly applies.

(*G 40*) Price ... ...

If desired, the grating and prism can be mounted on a metal plate on slides so that the prism system and grating can be readily interchanged one with another.

(*G 37*) Price for the combined instrument ... ...

For Littrow Type Spectrograph with quartz train, see *Section E.*

For photographic plates for spectrum work, see *Section F.*

Many other forms of spectroscopes and spectrographs have been made for astronomical work, but they are too numerous and varied for inclusion in this catalogue.

Particulars and designs for any special form will be supplied on application.

ULTRA-VIOLET STELLAR SPECTROGRAPH, Angular Aperture of Optical System F/5.

For use up to W.L. 3000.

The above Spectrograph (*see* Fig. G 38) has for optical system two 60° prisms of the most transmissive ultra-violet glass, and lenses of large aperture (F/5), also of ultra-violet glass. The lenses are figured to correct for spherical aberration in the axis.

The prisms have automatic adjustment for minimum deviation; and there is a division for setting the camera to any part of the spectrum. A small telescope is fixed to the cover (not shown in the figure) which receives the light reflected from the first prism surface for the purpose of following the star. The telescope and collimator have rack and pinion focussing with division for setting.

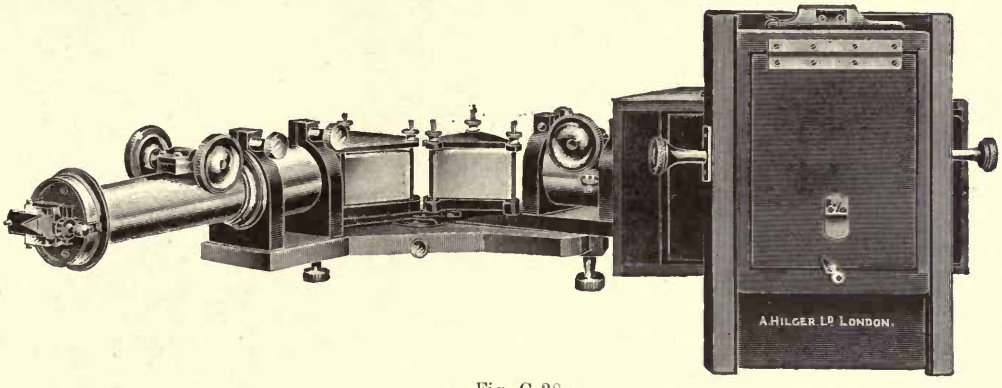


Fig. G 38.

SPECIFICATION.

Slit, our No. F 24. (*See* Spectroscope slits under Section F, p. F 5.)

2 prisms, 40 mm. high by 70 mm. long face, giving 40 mm. effective aperture for D.

Lenses 40 mm. clear diameter, 200 mm. focal length for W.L. 5461.

The dark slide takes plates $4\frac{1}{2}'' \times 3\frac{1}{4}''$, and a number of exposures can be taken on a $\frac{1}{4}$ plate.

Length of spectrum from W.L. 3000 to W.L. 8000 = 50 mm.

Total weight (including cover and following telescope) 9 lbs. (4·1 kilos.).

(*G 38*) Price ... ...

The above price does not include adaptation to the telescope on which the Spectrograph is to be used, the charge for which varies according to circumstances.

NOTE.—*With plain lenses of large aperture like the above it must be understood that only a small part of the spectrum can be obtained of good definition at one time; it is, however, easy to set the instrument rapidly for any chosen part of the spectrum between W.L.* 3000 *and W.L.* 8000.

Similar Spectrographs working at F/5 of larger size or with a quartz train can also be quoted for on application.

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March 1920.

SECTION J.*

POCKET AND OTHER DIRECT VISION SPECTROSCOPES.

DIRECT VISION SPECTROSCOPE for Rapid Spectroscopic Observation of Spark, Arc, or other light sources which, when viewed from any distance exceeding a yard or two, are approximately point sources.

This instrument has no slit, being similar in principle to the Ramsay Spectroscopes mentioned below; but with the addition of a combination of a fixed cylindrical with a movable spherical lens which extends the points of light into spectrum lines and enables one to focus them as in the ordinary Direct Vision Spectroscope.

Thus light sources at any distance can be examined and sharp lines obtained even by observers having imperfect power of eye accommodation.

(*J 19*) Price in brass case ... ...

Ramsay Spectroscope, for use in the rapid examination of vacuum tubes, small prism.

(*J 3*) Price ... ...

Ramsay Spectroscope, large prism.

(*J 4*) Price ... ...

(*J 5*) Brass case for either of the above ... ...

Direct Vision Pocket Spectroscope with fixed slit, 3½ inches long.

(*J 6*) Price with protective cap with glass window and brass case ...

(The above instrument is specially suitable for the observation of absorption bands, etc.)

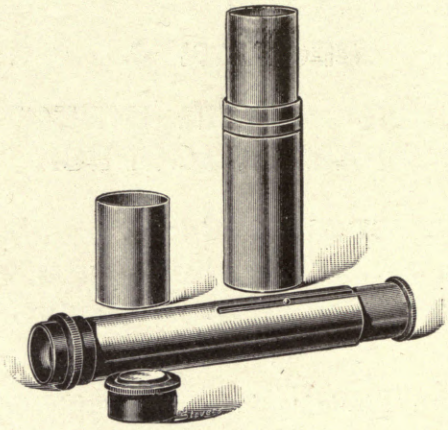

Fig. J 7.

Direct Vision Pocket Spectroscope, $3\frac{1}{2}$ inches long, with adjustable slit, prism of high dispersion and protective cap over the slit with glass window, in brass case (Fig. J 7). Suitable for absorption, emission, and rainband spectra.

(*J 7*) Price ... ...

Direct Vision Pocket Spectroscope, $5\frac{1}{2}$ inches long, with adjustable slit and large compound prism of high dispersion, in brass case. *See also* pp. J 4-5.

(*J 8*) Price ... ...

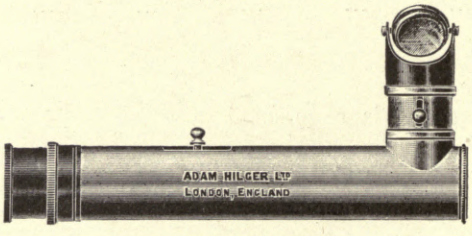

Fig. J 9.

Direct Vision Pocket Spectroscope, with photographic scale, and with rotating mirror for illumination of the same (Fig. J 9). The scale is reflected in the prism face so as to be seen in juxtaposition to the spectrum. These scales are exceptionally fine, and very good readings can be obtained with this instrument.

(*J 9*) Price in morocco case ... ...

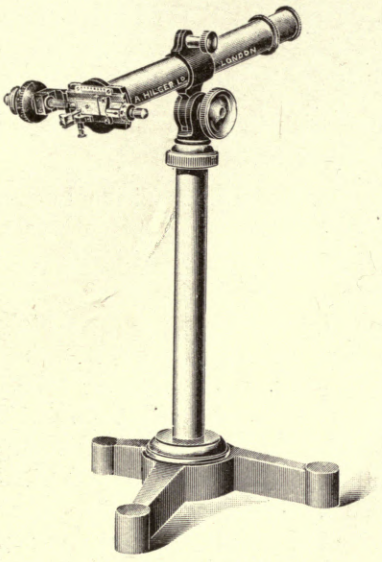

Fig. J 10, J 14.
Direct Vision Spectroscope, with Stand and Comparison Prism.

Direct Vision Spectroscope, 8½ inches long, with adjustable platinoid slit and divided drumhead, prism of high dispersion and positive eyepiece separating the sodium lines distinctly. A fine micrometer screw motion is provided for passing through the spectrum and a pointer enabling wavelength determinations to be made with considerable accuracy.

This instrument, together with a table stand and comparison prism (as illustrated), is highly suitable for laboratory work.

(*J 10*) Price ... ...

Comparison prism to J 10.

(*J 11*) Price (extra) ... ...

Morocco case for J 10.

(*J 12*) Price (extra) ... ...

Bright pointer for J 10, with reflecting mirror having universal motion to illuminate the pointer in any position of the spectroscope.

(*J 13*) Price (extra) ... ...

Table stand for J 10, on cast-iron tripod, with hinge clamp, universal tilting motion, and clamp for raising and lowering.

(*J 14*) Price ... ...

Direct Vision Pocket Spectroscope, mounted with **Film Replicas of Rowland's Diffraction Gratings,** 14,438 lines per inch, **Visible spectrum over 20°.**

(*J 15*) 5½ inches long, with adjustable slit, in brass case ... ...

DIRECT VISION POCKET SPECTROSCOPE WITH INTERFERENCE ETALON.

GLASS INTERFERENCE ETALON for use with Direct Vision Pocket Spectroscope, showing the Fabry & Perot Ring System.

With this accessory, which is designed to fit our J 8 Direct Vision Pocket Spectroscope (*see* p. J 2), the individual lines of a spectrum are subjected to a resolving power[1] of about 100,000. The Zeeman effect can be detected on suitable radiations (such as the yellow helium line), a distinct tripling of the line being visible.

The addition consists of an Interference Etalon of glass, that is, an accurately plane-parallel disc of glass, the polished surfaces of which are silvered to such a degree that only a small part of the light is transmitted, the majority being reflected. Light entering by the slit is then subjected to interference by multiple reflection within the plate in a manner analogous with that in the case of the Fabry & Perot Interferometers and Etalons.[2] The silver films on the surface are deposited with the greatest care in the manner recommended by Professor Fabry so as to obtain the most sharply defined and bright intensity maxima in the ring system, and a cover is provided for the protection of the silvered film when the Etalon is not in use.

The Etalon, E, is carried in a mount (as shown in Fig. J 18) which screws in

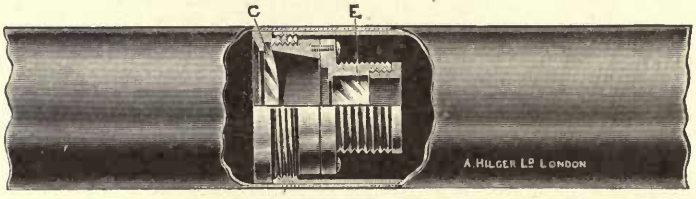

Fig. J 18.

place of the cell carrying the collimating lens of the Spectroscope. The mount carries its own collimating lens, C, and is provided with screws whereby the Etalon is set perpendicular to the axis of the Spectroscope. The position of the mount M in the Spectroscope is indicated in Fig. J 16, J 17.

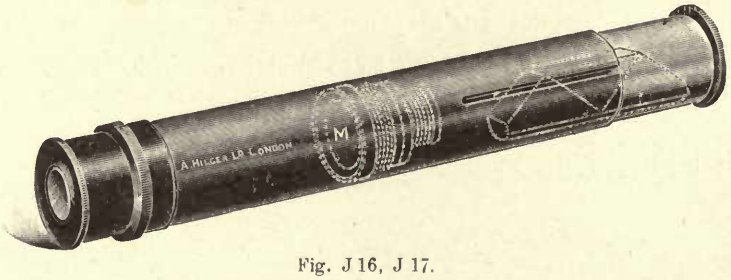

Fig. J 16, J 17.

[1] Resolving power $= \frac{\lambda}{\Delta\lambda}$ where λ and $(\lambda + \Delta\lambda)$ are in the wavelength of two radiations which can just be detected as separate.

[2] For bibliography concerning Fabry & Perot Interferometers, *see* p. N 6.

The instrument is suitable for use with any light source which emits radiations sufficiently intense and pure, such, for example, as a copper arc, a mercury vapour lamp, or a helium vacuum tube. When such radiations are examined, the following appearance is seen in the eyepiece :—

(1) The lines of the spectrum are visible in the same positions as they would occupy were the Etalon removed, but of course far less bright.

(2) Each spectrum line is a diametrical strip of the interference ring system produced by the light of that wavelength.

(*J 16*) Price of J 8 Direct Vision Pocket Spectroscope, $5\frac{1}{2}''$ long, with high dispersion compound prism ... ...

(*J 17*) Price of Etalon, including the adaptation to our Direct Vision Pocket Spectroscope J 8 ... ...

(*J 18*) Similar Etalons can be supplied adapted to any other Pocket Spectroscope. Price ... ...

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SECTION K.*

DIFFRACTION GRATINGS.

(*K 0*) **Rowland Diffraction Gratings.**—A stock of diffraction gratings, ruled at the Johns Hopkins University, both plane and concave, is always kept. The best quality only are stocked. Price lists and particulars of gratings in our stock will be sent post free on application.

For Concave Grating Spectrographs, *see* Section E.

Infra-red Diffraction Gratings.—Plane gratings, ruled on brass, 946 lines per cm., specially cut to give maximum intensity in the 1st order spectrum on one side of wavelength 4·40 μ.

The polished surface is $6\frac{1}{2} \times 5$ cms.

The ruled surface is 5×4 cms.

(*K 1*) Price ... ...

For Wavelength Spectrometer, Constant Deviation Type, with Diffraction Grating, see *Section D, "Wavelength Spectrometers."*

Film Replicas of Rowland's Diffraction Gratings. (14,438 lines per inch.)

Mounted on best plane parallel worked glass, for use with table spectroscope, specially selected gratings.

(*K 3*) Price, in morocco case ... ...

Mounting with three levelling screws for either of above gratings.

(*K 4*) Price ... ...

Mounted in $5\frac{1}{2}$ inch long direct vision pocket spectroscope, with adjustable slit in brass case. *Visible spectrum over* 20°.

(*K 5*) Price ... ...

Mounted on field glasses (adapted to customers' own instruments) for eclipse observations.

(*K 6*) Price ... ...

Photographed Gratings, 3,610 lines per inch, for demonstration purposes.

(*K 8*) Price ... ...

Replicas of interest in connection with the ruling of Diffraction Gratings.—A set of replicas of three gratings ruled in the following way :—

(*K 9*) Uniform ruling. Spacing $\frac{1}{1800}$ inch.
(*K 10*) Alternate ruling. Spacing $\frac{1}{3600}$ inch.
(*K 11*) Ratio of spacing $\frac{1}{7200} : \frac{3}{7200}$.

In the first, all spectra are present and bright; in the second, alternative spectra are weak or absent; in the third every fourth spectrum is missing.

Owing to the coarseness of ruling a considerable number of spectra are visible on each side of the central image.

Each replica is mounted on plane parallel glass and is of good definition for demonstration work.

Price per set of three (limited number only available) ...

For Michelson Echelon Diffraction Gratings, see our separate Illustrated List B.

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SECTION L.*

MICROMETERS, Etc.

NOTE.—*The term "Micrometer" is often applied indiscriminately to any screws of fine pitch, sometimes even to screws cut with dies. We wish it to be noted that we invariably imply by it a screw well cut between dead centres on a special lathe with tested screw, and fitted and ground into its nut with due care and skill.*

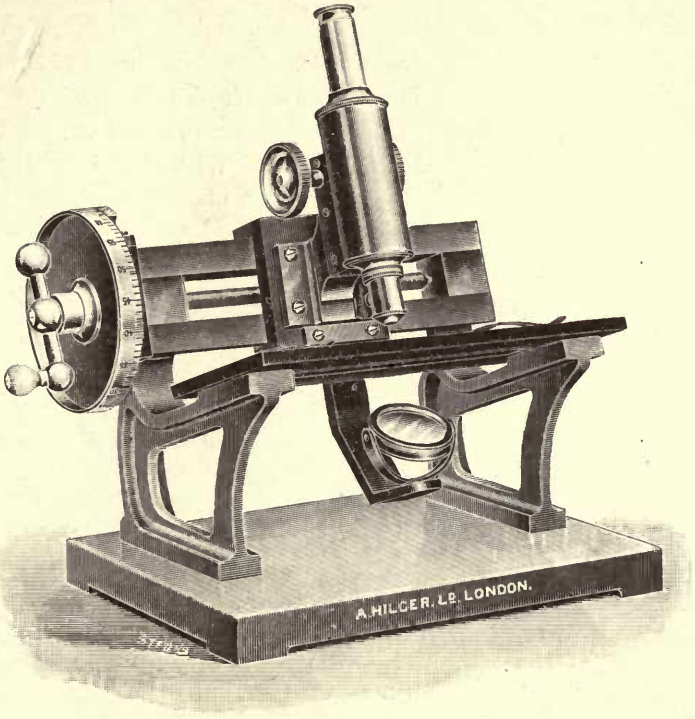

Fig. L 1.

Photomeasuring Micrometer, 1913 *MODEL* (Fig. L 1).—The latest model of this instrument has the following modifications, which experience has shown to be of very great value in facilitating readings:—

The mirror moves with the travelling microscope.

The milled head for turning the screw has been replaced by a handle.

The standards which support the slide and substage are so designed that the axis of the microscope is sloped towards the observer.

A vernier has been added, reading to 0·001 mm.

Though specially designed for accurate and rapid measurements of spectrum photographs, this instrument can be used with equal advantage for any of the accurate length measurements the need for which so often arises in a laboratory.

The objects aimed at in its construction are:—

i. Accuracy.
ii. Long life under frequent use.
iii. Rapidity and convenience of working.

I. Is attained by the greatest care being exercised in the manufacture of the steel screw, its nut, the gunmetal slide which bears the microscope, and the shoulder fitting of the screw.

II. Is attained by strict simplicity of design, and by the provision of adequate bearing surfaces in screw and microscope slide. The deep thread of the screw and its substantial diameter are the main points to be noted in this respect.

III. Is attained by making the screw of fairly large pitch, *i.e.*, 1 mm., and putting on a specially large divided drumhead and vernier. With the aid of the handle now provided, one can pass rapidly over the whole range of motion, while at the same time the large drumhead enables measurements to be taken to 0·001 mm.

The base is of cast-iron, and the microscope slide is mounted on two cast-iron standards, of such a shape as to form convenient handles for moving the instrument.

(*L 1*) Price, with 6-inch (152 mm.) travel ... ...
(*L 2*) Price, with 3-inch (76 mm.) travel ... ...

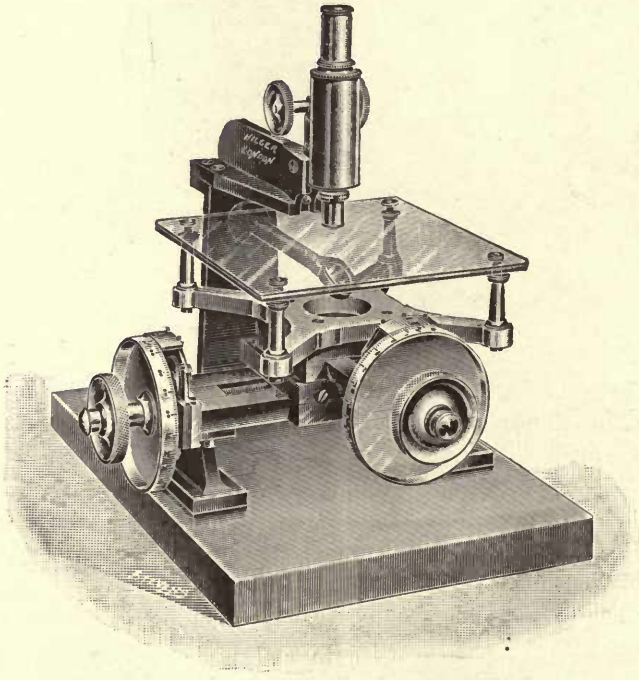

Fig. L 3.

NEW MODEL CROSS-SLIDE PHOTOMEASURING MICROMETER. Fig. L 3.

In this instrument the photographic plate moves, the microscope being rigidly fixed. Six inches (152 mm.) of motion is provided in two directions at right angles to each

other, the distance being measured by accurate screws similar to those of the instrument described above, massively and rigidly mounted, and of the highest accuracy.

(*L 3*) Price (6-inch travel in two directions at right angles to each other)

"Standard" Spherometer (Ring Form). Fig. L 6, L 8.

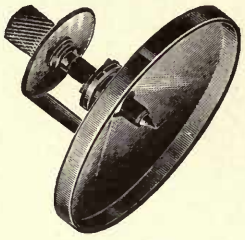

Fig. L 6, L 8.

This form of spherometer has a ring instead of the usual three legs. The ring is ground so as to have two truly circular edges, one of which makes contact with concave surfaces, and the other with convex surfaces. The inside and outside diameter are accurately measured. With this instrument readings can be obtained as reliable as those of the most elaborate instruments obtainable.

(*L 6*) Price, in case, 1 inch, radius ... ...

(*L 8*) ,, ,, 2 ,, ...

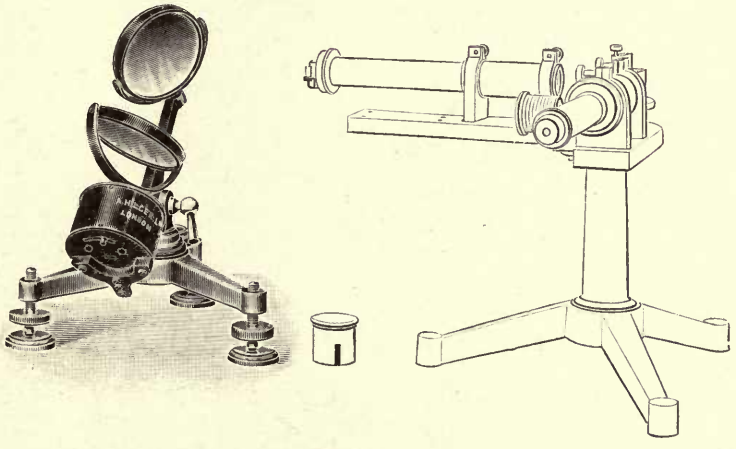

Fig. L 7.

Heliostat for use with Table Spectrometers, see Fig. L 7; which shows the heliostat in position before a Wavelength Spectrometer.

These heliostats have mirrors which are optically polished, but are not of first quality. The mirrors are silvered on the back.

The clock motion is sufficiently good to ensure light from the sun being reflected on to the slit of a spectrometer for many hours without readjustment.

(*L 7*) Price ... ...

Larger sizes with optically plane silvered glass or speculum metal mirrors quoted for on application.

ADAM HILGER, Ltd., 75a Camden Road, London, N.W. 1

Telegraphic Address—"Sphericity, Phone, London."
Telephone—North 1677/8.
Cable Code—Western Union.

March 1920.

SECTION M.*

POLARIMETERS AND REFRACTOMETERS.

We strongly recommend that where feasible the light of the Mercury Vapour lamp should be used in place of the Sodium flame. Greater accuracy and far greater comfort and convenience of reading are thus obtained (see *Lowry*, "*The Rotatory Dispersive Power of Organic Compounds*," Trans. Chem. Soc., 1913, *vol.* 103, *p.* 1064). *Commercial Mercury Vapour lamps are now easily to be purchased from various sources.*

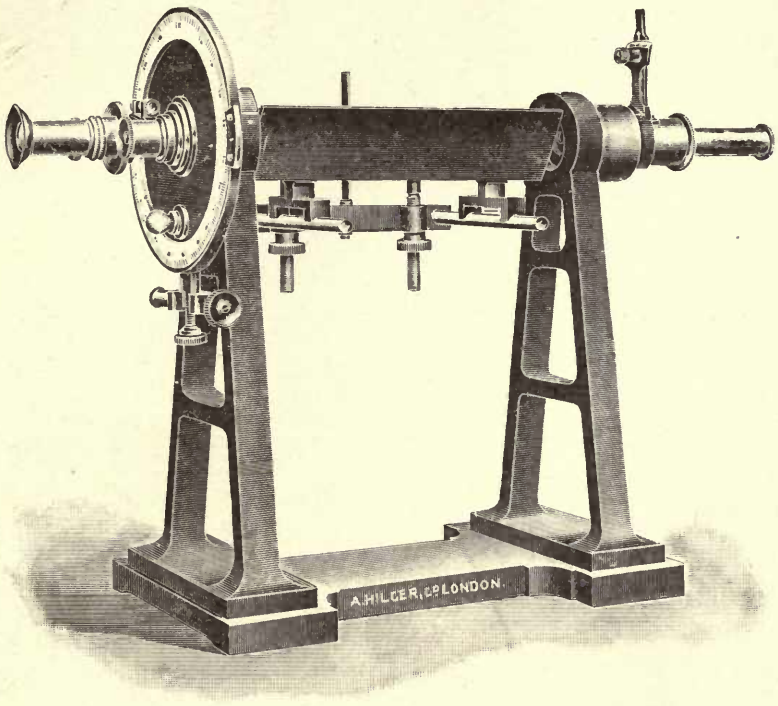

Fig. M 2.

The more recent model of our Polarimeter, as shown in Fig. M 2, *has been greatly improved in design. By removal of the trough and its support a clear space can be left in between polariser and analyser for such accessories as heating apparatus, electro-magnet, etc.*

Further improvements are the following:—

The slow motion adjusting screw is of almost non-tarnishable metal. All parts of the instrument are well protected against chemical corrosion, either by extremely refractory enamel, or by special lacquer very carefully selected for its power of resistance to chemical action. Thus the instrument is very suitable for use in a chemical laboratory.

Polarimeter (Fig. M 2).—Taking tubes for liquids 200 mm. long; with screws for raising and lowering and levelling, and slides for sideway adjustment for centring the tube.

The polarising system is of the Lippich form, in which the field of view is as shown in Fig. M 2 A.

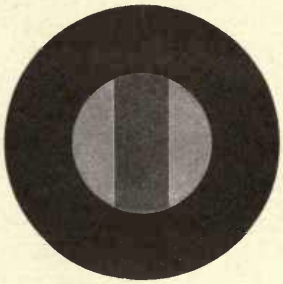

Fig. M 2 A.

The illumination of the middle strip decreases in intensity when the outer increases, and *vice versâ*. The brightness of the illumination can be varied by rotation of the polarising prism; and an index and clamp are provided for the setting of this adjustment.

The divided circle is 7 in. diameter, and the division is on platinoid, which does not readily tarnish. There are double verniers, reading to 0·01 degree, and readers and illuminating lamps for the same. There is a good screw slow motion with clamp for fine adjustment of the analyser.

The work throughout is of the highest quality.

(*M 2*) Price, with tube for liquids ... ...

(*M 3*) With International Sugar Scale in addition to the ordinary division, extra ... ...

(*M 4*) Well-made case, with lock and key ... ...

Polarimeter, as above, but taking tubes 400 mm. long, the construction being otherwise identical.

(*M 5*) Price, with tube for liquids ... ...

(*M 110*) Well-made case, with lock and key ... ...

Addition of Direct Vision Spectroscope attachments to either of the above, consisting of slit at polariser end (formed by shutters pushing in by hand in front of Lippich polariser), and one high dispersion direct vision prism in mount screwing on in front of the eyepiece.

(*M 6*) Price ... ...

The above direct vision prism can be supplied direct for the red, green, or violet, as desired.

(*M 7*) Extra prisms mounted, price each ... ...

(*S 6*) Sodium burner, with bottle of fused borax ... ...

SPECTRO-POLARIMETER.

(*For measurements on the rotatory power for radiations of any desired wavelength.*)

This instrument (Fig. M 8-M 10) consists of a wavelength spectrometer, as described on pp. D 1 to D 4, reading in wavelengths direct, a polariser, and an analyser—all mounted on an accurate cast-iron bed. An image of the spectrum is projected on to the plane of the dividing lines of the Lippich triple field Polariser, which dividing lines are in this instrument set horizontal.

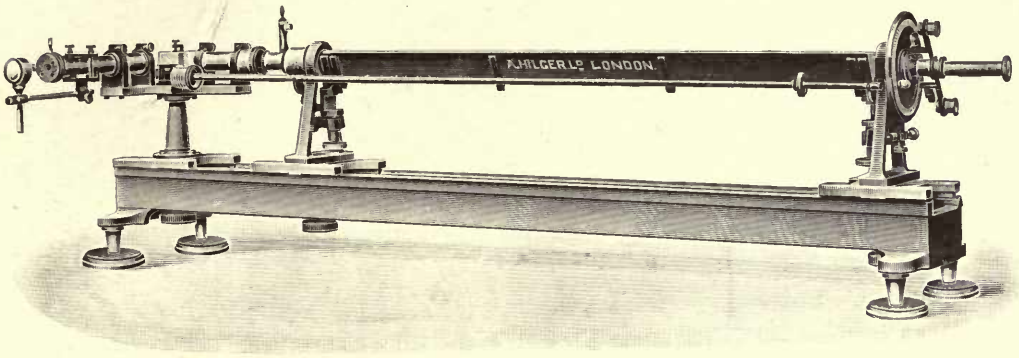

Fig. M 8-M 10.

Close to these dividing lines, and between them and the eye, are two shutters pushing in by hand, which limit the field observed to a strip of monochromatic light. The slit of the spectrometer opens symmetrically.

The three standards carrying the spectrometer, polariser, and analyser can be clamped in any desired position on the bed.

A suitable condensing lens is mounted on the collimator of the spectrometer, and a rod with milled head is provided for passing through the spectrum without quitting the eye end of the apparatus. The polariser and analyser are identical with those in the instruments described on pp. M 1 and M 2.

(*M 8*) Price, taking tubes up to 200 mm. long ... ...
(*M 9*) Price, taking tubes up to 400 mm. long ... ...
(*M 10*) Price, taking tubes up to 1000 mm. long ... ...

Owing to the impossibility of entirely avoiding faint diffused light of mixed wavelengths it is highly necessary to use in conjunction with this apparatus the direct vision spectroscope attachments described at the bottom of p. M 2.

(*M 11*) Price, extra, for the complete set with three prisms ...

PRICES OF POLARIMETER TUBES.

All these Tubes are accurate in length to $\frac{1}{1000}$ *inch.*

Length of Tube.	Ordinary Glass Tubes.	Ordinary Glass Tubes with enlarged end.	Inversion Tubes.
25 mm.	(*M 111*)	(*M 119*)	(*M 127*)
50 mm.	(*M 112*)	(*M 120*)	(*M 128*)
100 mm.	(*M 113*)	(*M 121*)	(*M 129*)
200 mm.	(*M 114*)	(*M 122*)	(*M 130*)
220 mm.	(*M 115*)	(*M 123*)	(*M 131*)
400 mm.	(*M 116*)	(*M 124*)	(*M 132*)
600 mm.	(*M 117*)	(*M 125*)	(*M 133*)
1000 mm.	(*M 118*)	(*M 126*)	(*M 134*)

PULFRICH REFRACTOMETER.*

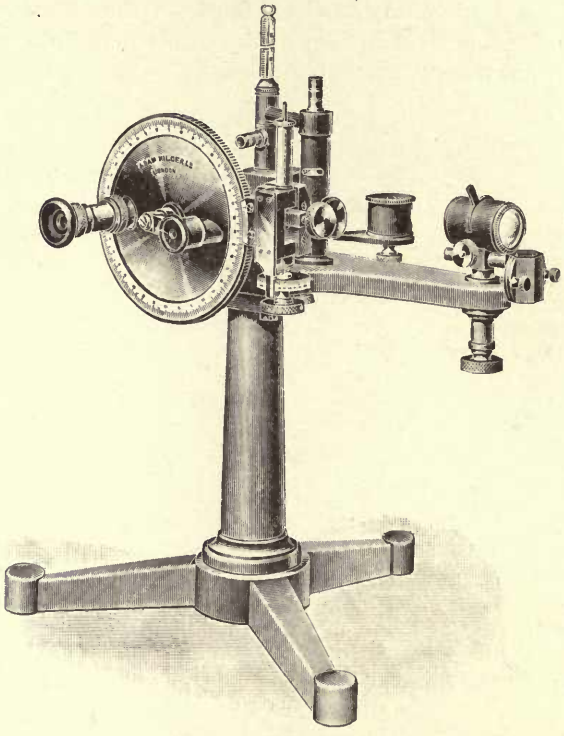

Fig. 48.

This instrument is designed for the measurement of the refractive indices of both solids and liquids with an accuracy of about ·0001 ; and also the dispersion (*i.e.* the difference of refractive index for two spectral lines) to about ·00002.

A very efficient water jacket forms an integral part of the instrument, and not only allows of the temperature being effectively controlled, but also permits of measurements being made upon some substances in the liquid state which are not liquid at atmospheric temperature.

Description of the Apparatus.—A glass prism of high refractive index has two plane polished faces which are perpendicular to one another, and is so placed that one of these is vertical and the other horizontal. The substance whose refractive index is required is placed upon the horizontal surface, and in the case of a liquid is contained in a glass cell cemented to the prism so as to contain that face. A beam of monochromatic light is directed almost horizontally through the substance so that it meets the prism face at grazing incidence. The emergent beam is bounded sharply by that ray which actually grazes the prism surface, and the sharp boundary is

observed with a telescope attached to a divided circle. On this circle, whose axis of rotation is horizontal, the angle of emergence of the beam from the vertical prism face can be read to one minute with the aid of a vernier. For making measurements of dispersion a clamp and micrometer screw are provided, the smallest division on the drum head of the micrometer screw corresponding to 6 seconds of arc. A condensing lens and supporting rod for vacuum tube form part of the apparatus.

A small reflecting prism is also provided so that another source of light, *e.g.* a sodium flame, is easily interchangeable with the vacuum tube.

A special feature of the instrument is the increased effectiveness in the temperature control as compared with that to be found in previous designs. The hollow metal water jacket surrounding the prism is provided with a top cover which is itself of hollow metal. These two are connected in train with the thermometer jacket which dips into the cell for liquids. The prism and substance experimented upon are thus completely jacketed with the exception of the vertical prism face from which the light emerges, and a small rectangular aperture by which the light enters the prism. The temperature can thus be maintained very constant by pumping a stream of water at constant temperature through the system described.

We recommend a Lowry Thermostat for this purpose.

The thermometer provided is sufficiently sensitive to attain its final temperature in less than 30 seconds.

Theory of the Instrument.—The angle of emergence of light from the prism is connected with the refractive index of the substance to be measured in the following way:—

Let μ = required refractive index.

μ_0 = refractive index of prism.

i = angle of emergence.

Considering the refraction at the two prism faces in turn we have :

$$\sin \frac{\pi}{2} = \frac{\mu_0}{\mu} \sin \left(\frac{\pi}{2} - r\right)$$

$$\sin i = \mu_0 \sin r.$$

Combining these equations :

$$\mu = \sqrt{\mu_0^2 - \sin^2 i}.$$

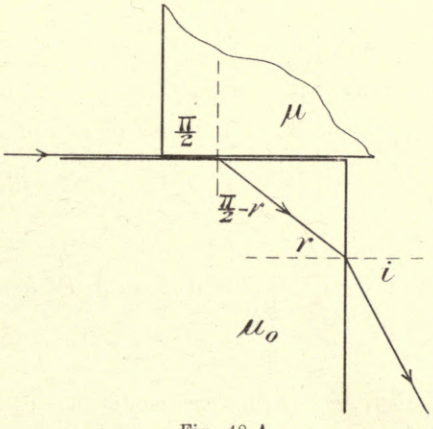

Fig. 48 A.

A table giving corresponding values of μ and the angle i is supplied with every prism.

It will be noticed that the refractive index to be measured must be less than that of the glass of the prism. For this reason two prisms are supplied, one suitable for measurements on liquids, and the other for measurements on solids, such as samples of glass, etc. In the case of solids also the specimen to be investigated must have two perpendicular faces meeting in an unbroken line, while one of them (viz. that which comes in contact with the prism face) must be plane and fairly well polished.

Optical contact is made with the prism by means of a drop of some liquid of higher refractive index than that of the solid to be investigated (*e.g.* monobromonaphthalene).

BIBLIOGRAPHY.

Zeitschrift für Inst. (1888), vol. viii., page 47.

C. Pulfrich, *Das Totalreflektometer und das Refraktometer für Chemiker u.s.w.*, Leipzig (1890).

Zeitschrift für Inst. (1895), vol. xv., page 389.

Zeitschrift für Phys. Chemie (1895), page 294.

Journal de Physique, (3) t.V. (1896), page 73.

Astrophysical Journal, vol. iii., No. 4 (1896), page 259.

Damien and Paillot, *Traité de Manipulations de Physique*, Paris (1896), page 207.

Arbeiten der Physikalischen Abteilung der kaiserlich russischen Gesellschaft von Freunden der Naturwissenschaft u.s.w., Moscow (1896), vol. viii.

The instrument described above is essentially the same in principle as that described in the references, but is of improved design. It is very substantially made, and will bear constant usage without risk of damage to any important part.

Pulfrich Refractometer with prism of refractive index D. of 1·74 for substances of refractive indices for D. between 1·47 and 1·73, with mount and carrier and improved water jacketing attachments.

(*M48*) Complete in case with lock and key ... ... Price

(*M56*) Hydrogen End-on Vacuum Tube ... ... Price extra

Prism of refractive index for D. of 1·62, for liquids of refractive indices for D. between 1·33 and 1·61, with mount and carrier and with glass cell for liquids.

(*M57*) ... ... Price extra

(*M58*) Thermometer ... ... Price extra

Quotation for a suitable thermostat to be used with the Refractometer will be sent on application.

Abbe Refractometer. For full particulars of this instrument see separate booklet, sent post free.

JAMIN REFRACTOMETER.

(*Full description, abstracted from Jamin's original paper in the "Ann. de Chim. et de Phys.," 3rd series,* tome lii. p. 163, 1858, *sent out with each instrument or post free on application.*)

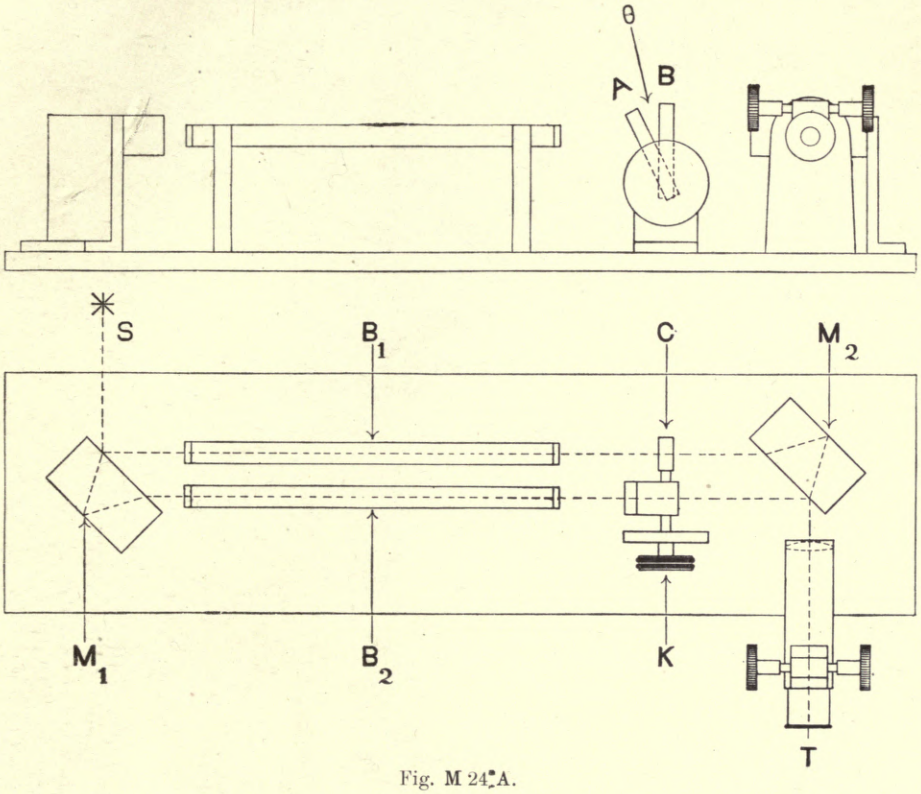

Fig. M 24 A.

The Jamin Refractometer, as supplied by us (for price *see* below), is shown in Fig. M 24 and in diagram in Fig. M 24 A.

Light from any convenient source S is divided by the mirror M_1 (silvered on the back) into two beams; the first is reflected from the exterior face and passes along the tube B_1, the second is reflected from the interior silver face and passes along the tube B_2.

After traversing the two tubes (which contain, the one the gas or liquid under test and the other that with which it is to be compared), the two beams pass through the plates of the compensator C (*see* Fig. M 24 A). Falling on the mirror M_2, which is identically the same as M_1, and parallel to it, the beams experience reflections inverse to those to which they were primarily subjected, with the result that they are superimposed under conditions suitable for interference.

PRICES.

Jamin Refractometer (*see* Fig. M 24) giving a separation between the centres of the beams of 18 mm., and taking tubes 250 mm. long. The observation telescope has rack

and pinion for focussing and cross-webs in the eyepiece. Two tubes for gases are provided. Means are provided for altering the angle between the compensator plates,

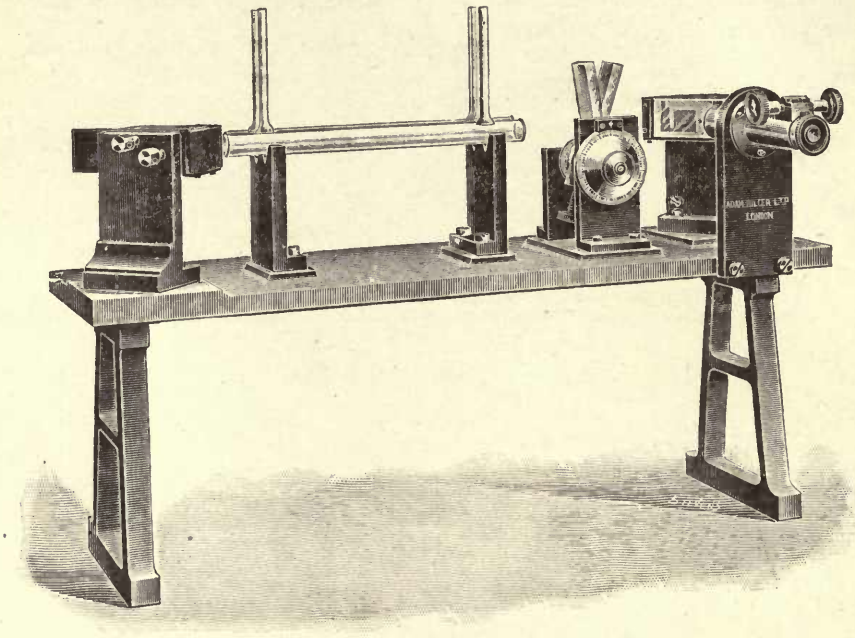

Fig. M 24.

and the rotation of the plates is read by vernier to 0·1°. All optical work is of the highest quality.

(*M 24*) Price ... ...
(*M 25*) If the tubes are to be sufficiently accurate for work on liquids, price extra for the pair of tubes ... ...

Jamin Refractometer with worm-wheel motion for rotating the compensator plates and accurately divided circle for same, reading by vernier to ·02°. Screw-motion for altering the sensitiveness by rotation of one compensation plate relative to the other. Separation of beams of 30 mm., and taking tubes 500 mm. long.

(*M 26*) Price ... ...
(*M 27*) If the tubes are to be sufficiently accurate for work on liquids, price extra for the pair of tubes 250 mm. long ...

(We do not supply tubes for liquids 500 mm. long.)

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March 1920.

SECTION N.*

MICHELSON AND FABRY & PEROT INTERFEROMETERS.

See also for Fabry & Perot Etalons—

p. O 3, *Fabry & Perot Etalon ;*

p. O 6, *Mount for taking the above in front of any ordinary Spectroscope ;*

p. J. 5, *Direct Vision Pocket Spectroscope, with Interference Etalon.*

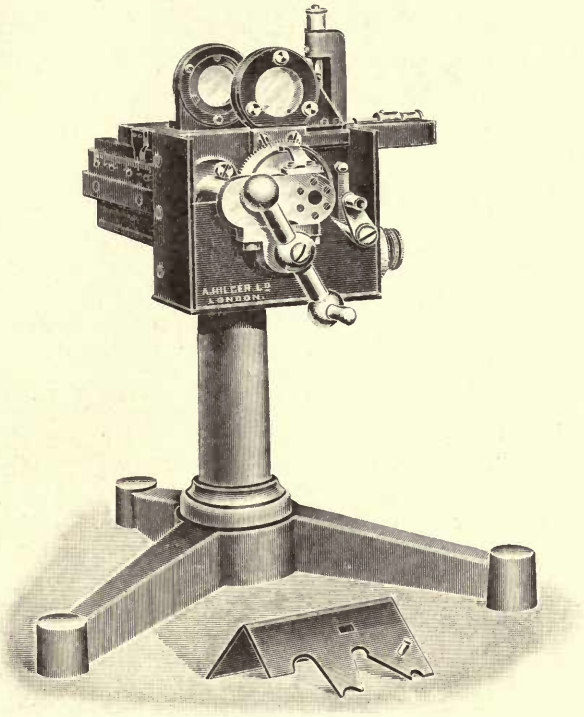

Fig. N 1.

The transmission plates in the following interferometers are silvered by cathodic deposition from fresh electrolytically deposited silver. With silver films deposited in this manner the loss of light is less than by any other known method, and the necessary condition for sharply defined and bright intensity maxima is thus fulfilled. In the case of the Fabry & Perot Interferometers the plates are made slightly wedge-shaped in the usual manner to avoid the secondary interference systems caused by reflection at the unsilvered outer surfaces.

Our latest models of **Michelson** and **Fabry & Perot Interferometers**—those, namely, sent out during or after August 1912—are in every case so arranged that either the Fabry & Perot or the Michelson system of mirrors can be supplied at any subsequent time and attached without any alteration of the apparatus.

Three sizes are made, having respectively 75 mm., 120 mm., and 200 mm. travel of the movable mirror. The 200 mm. size is supported on a tripod of special form (*see* Fig. N 8). Otherwise, except as regards the lengths of the slides and of the micrometer screws, all three sizes are of identically the same construction, both as to accuracy of workmanship and dimensions. Thus a set of mirrors suitable for any one size is also suitable for any other.

The micrometer screws have 1 mm. pitch. The divided head attached to the screw has 100 divisions, and one turn of the slow motion screw, whose head is also divided into 100 parts, corresponds to one division on the main drumhead. Thus one division on the drumhead of the slow motion screw corresponds to $\frac{1}{10,000}$ mm. (one ten thousandth of a millimetre).

The slides are massive, and of steel,* and the sliding surfaces are worked *optically flat*. The slides are heavily protected by hard enamel, with the exception of the actual sliding surfaces. Only these sliding surfaces, therefore, require care to avoid rust. A bottle of suitable oil is provided, which it is well to use freely on the slides, and occasionally on the screw. The most recent construction of the slides is the result of many experiments, and is such that we are able to make them flat to a high optical precision, thus securing the desired accuracy in maintaining the parallelism of the movable mirror in its progress from one end of the slide to the other.

The slow motion mechanism has a carefully made cover, which can be readily removed, if desired, for inspection.

The micrometer screws are cut between dead centres and ground at constant temperature, and are made throughout with the very greatest care. Their position is determined longitudinally by a plate of polished quartz at the end towards the observer, which end takes the thrust when the mirror is moving in the direction of increasing optical path. A system of opposing screws enables this plate to be set up perpendicular to the axis of rotation of the micrometer screw, whose end is polished to an approximately flat surface. Thus by reflecting light in the direction of the axis of the screw through the thickness of the quartz block (which is polished on both surfaces to enable the end of the screw to be thus observed), one can observe the interference fringes produced between the light reflected from the thrust-taking surface of the quartz and the polished end of the micrometer screw. Observation in this manner enables the adjustment of the plate of quartz perpendicular to the axis

---

* *The slides are made from forgings of specially selected steel, the preparation and treatment of which to avoid subsequent deformations are carried out for us by Sir W. G. Armstrong, Whitworth & Co., whose experience in the construction of standard screw gauges has enabled them to supply us with a material excellently well adapted for the purpose in view.*

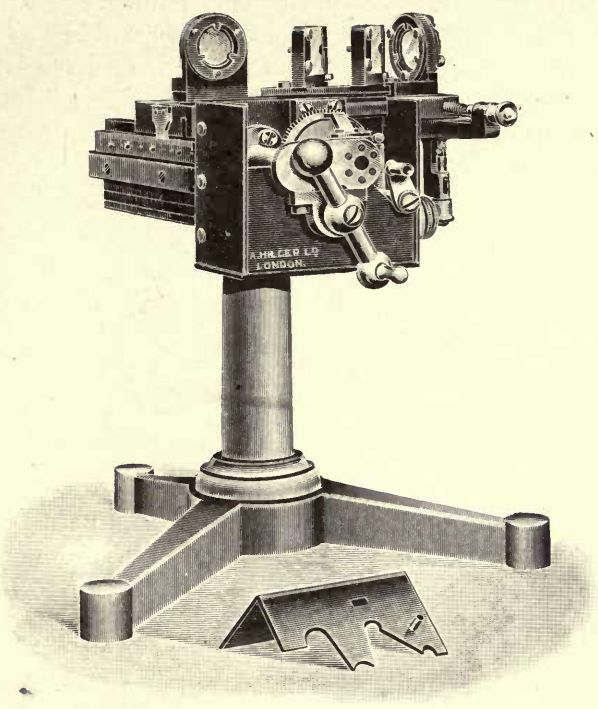

Fig. N 4.

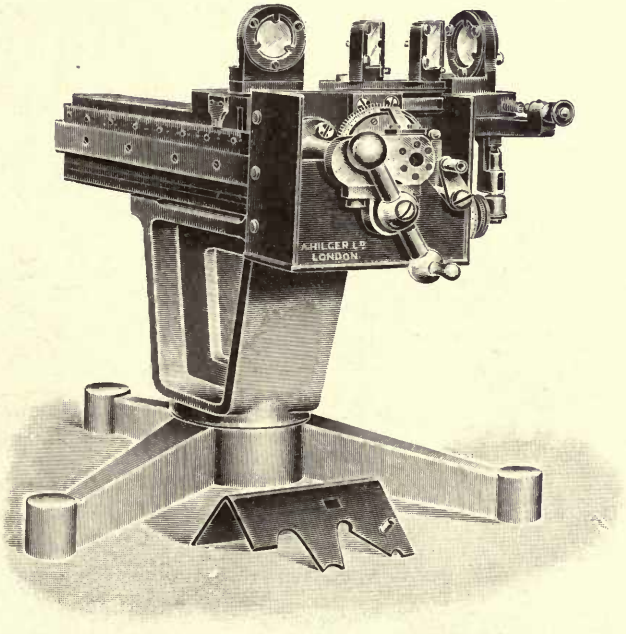

Fig. N 8.

of rotation of the screw to be made with great and ascertainable precision. The other end of the micrometer screw thrusts against the polished end of a fixed screw, by means of which one is enabled to reduce the longitudinal play of the micrometer screw to a minimum, without introducing any longitudinal compression. The carriage can be removed by lifting it off its slide, and can be as easily replaced. The two thrust blocks under the carriage, which engage with the nut of the micrometer screw, are so adjusted as to allow a small amount of lost time. A convenient spring adjustment is provided for one mirror, which, while enabling the delicate final adjustment for parallelism to be made with great precision, is nevertheless so substantial as to introduce no trouble from vibration.

Fabry & Perot Interferometer, latest design as described above—

(*N 1*) Price, with 75 mm. motion of the carriage (Fig. N 1) ...

(*N 2*) Price, ,, 120 mm. ,, ,, ...

(*N 3*) Price, ,, 200 mm. ,, ,, ...

Set of Michelson mirrors, with mounts and spring adjustments complete, as shown in Fig. N 4, suitable for immediate attachment to any of the above instruments—

(*N 4*) Price ... ...

(*N 5*) Case to take both sets of mirrors, with their mounts. Price ...

Michelson Interferometer—

(*N 6*) Price, with 75 mm. motion of the carriage ... ...

(*N 7*) Price, ,, 120 mm. ,, ,, ...

(*N 8*) Price, ,, 200 mm. ,, ,, (Fig. N 8) ...

Set of Fabry & Perot mirrors suitable for immediate attachment to any of the above instruments—

(*N 9*) Price ... ...

(*N 10*) Case to take both sets of mirrors, with their mounts. Price ...

Levelling Screws to either Fabry & Perot or Michelson Interferometers—

(*N 11*) Price, 75 mm. or 120 mm. sizes ... ...

(*N 12*) Price, 200 mm. size ... ...

Well-made case, with lock and key, for either Fabry & Perot or Michelson Interferometer—

(*N 13*) Price, 75 mm. size ... ...

(*N 14*) Price, 120 mm. size ... ...

(*N 15*) Price, 200 mm. size ... ...

The instruments with levelling screws are of suitable height for use in front of the slit of the Hilger Wavelength Spectrometers (Constant Deviation Type).

(*N 16*) **Achromatic Lens** 6″ (150 mm.) focal length in mount for attachment to the Fabry & Perot Interferometer, with focussing adjustment. This lens enables an image of the diffraction pattern to be thrown on the slit of a spectrometer, the dispersion of which then gives the necessary separation of the overlapping monochromatic fringes. The screw-holes for attachment of this lens are provided on all interferometers sent out subsequent to 30th August 1912. ... ...

Special Mercury Green Line Filters cemented in optically-worked glass—

(*a*) Transmitting only $\frac{1}{2}$ per cent. of the yellow lines and 72 per cent. of λ 5461 ; 2″ (51 mm.) square—

(*N 17*) Price ... ...

(*b*) Transmitting 0·0025 per cent. of the yellow lines and 50 per cent. of λ 5461, 2″ (51 mm.) square—

(*N 18*) Price ... ...

The (*b*) filters above can also be supplied 16 mm. clear aperture, mounted in brass tube, 30 mm. long—

(*N 19*) Price ... ...

(These screens are made for us by Messrs Kodak, Ltd., from glass prepared by ourselves.)

Plates for Interferometers.

(*N 20*) Circular mirrors for Michelson Interferometers, 25 mm. dia., each

(*N 21*) Transmission and compensation plates for Michelson Interferometers, 40 mm. long × 25 mm. high, each ... ...

(*N 22*) Complete set of Michelson Interferometer mirrors and plates as above—the set ... ...

Circular plates, silvered by cathodic deposition (*see* p. N 1), for Fabry & Perot Interferometers, of special construction, as used on our Fabry & Perot Interferometers (*see* Fig. N 23), permitting the interior surfaces to be brought close together. The diameter of the silvered surfaces is 25 mm.

(*N 23*) Price per pair ... ...

(*N 24*) Price, if of quartz, the plates being coated with nickel by cathodic deposition, for ultra-violet work, per pair ... ..

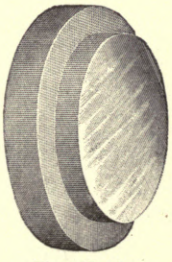

Fig. N 23.

Small Observation Telescope, with cross webs for viewing the fringes, on raising and lowering stand.

(*N 25*) Price ... ...

BIBLIOGRAPHY—Fabry & Perot Interferometers.

The bibliography has been chosen from the most important literature on the principles and methods involved in these instruments.

Annal. Chim. Phys. (7), *12*, page 459 (1897).
,, (7), *16*, page 115 (1899).
,, (7), *16*, page 289 (1899).
Comptes Rendus, *130*, page 406 and page 492 (1900).
Journal de Physique (3), *9*, page 369 (1900).
Annal. Chim. Phys. (7), *22*, page 564 (1901).
,, (7), *24*, page 119 (1901).
,, (7), *25*, page 98 (1902).
Comptes Rendus, *138*, page 676 (1904).
Annal. Chim. Phys. (8), *1*, page 5 (1904).
Comptes Rendus, *138*, page 854 (1904).
Journal de Physique, *3*, page 842 (1904).
,, *4*, page 245 (1905).
Comptes Rendus, *140*, pages 848, 1136 (1905).
,, *144*, page 1082 (1907).
Journal de Physique, March (1908).
,, June (1908).
Astrophys. Jour., *31*, 97, March (1910).
Ann. d. Physik, *43*, page 1117 (1914).
Phil. Mag., *27*, page 126 (1914).

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March 1920.

SECTION O.*

SPECTROSCOPIC APPARATUS FOR HIGH RESOLVING POWER.

(See also our separate Lists of larger Echelons, of Lummer-Gehrcke Parallel Plates, and of Interferometers, and p. J 5 for small etalon attachment in Pocket Spectroscope.)

THE instruments described on this and the six following pages are

(*a*) A Michelson Echelon Diffraction Grating,

(*b*) A Lummer-Gehrcke Parallel Plate,

(*c*) A Fabry & Perot Etalon,

together with apparatus specially designed for use with the above.

Although designed primarily for demonstration work, they are all optically as perfect as our larger apparatus of the same kinds (for which see the lists cited above).

They are of a size and design suitable for use on most ordinary Spectroscopes, but are especially useful in conjunction with the modified form of Hilger Wavelength Spectrometer (Constant Deviation Type) described below. Thus applied, the Fabry & Perot Etalon affords a means of determining wavelengths to a very high accuracy; while either the Echelon or the Lummer-Gehrcke Plate will demonstrate the Zeeman effect, the effect of pressure on the lines of the spectrum, or the minute structure of

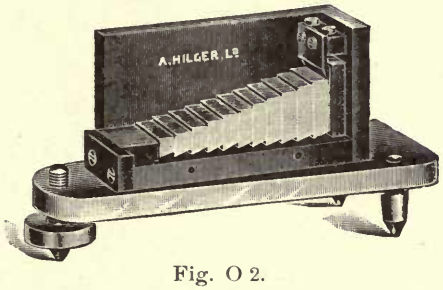

Fig. O 2.

any desired lines with a minimum of trouble and with the great intensity of light which distinguishes these powerful devices for high resolving power. At the same time the approximate wavelengths of the lines under observation can be read off direct from the drum of the Wavelength Spectroscope (*see* descriptive leaflet of the Hilger Wavelength Spectrometer, Constant Deviation Type).

The mode of application to the Wavelength Spectrometer has the further great advantage that a large number of lines of the spectrum can be examined at one and the

same time, all the lines which are visible in the eyepiece being simultaneously subjected to the analysis of the Echelon, or of the Lummer Plate, or of the Fabry & Perot Etalon, as the case may be.

(*a*) **Echelon** (*see* Fig. O 2) of highest quality, in mount complete. Suitable for use on any ordinary Spectroscope (in which case an auxiliary analysis of the light is necessary) or on the modified form of wavelength spectrometer described below, in which case the combined apparatus is complete in itself.

Number of plates, 12.	Effective aperture, 29 mm. × 13 mm.
Thickness of plates, 10 mm.	Resolving power, 100,000, for W.L. 5461.
Width of step, 1 mm.	

(*O 2*) Price in mount complete ... .

The accurate thickness of the plates and the optical properties of the glass are in every case engraved on the mount.

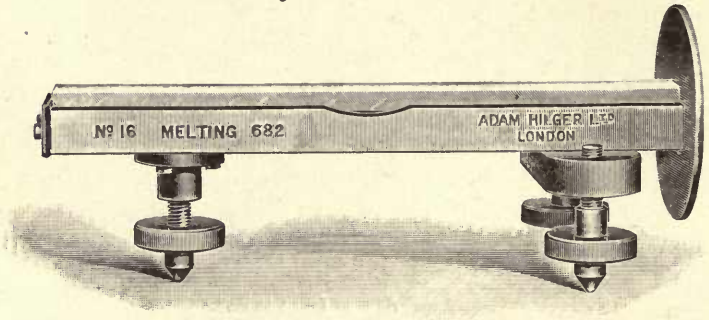

Fig. O 3.

(*b*) **Lummer-Gehrcke Plate** (*see* Fig. O 3), in mount complete. Like the Echelon above, this can be used on any ordinary Spectroscope, or preferably on the modified form of Spectrometer described below.

Length of plate, 130 mm.	Length over all of mount, 135 mm.
Width of plate, 15 mm.	Resolving power, about 200,000.
Thickness of plate, 4½ mm.	

(*O 3*) Price in mount complete ... ...

The thickness of the plate and optical properties of the glass of which it is made are engraved on the mount.

We can also supply Lummer-Gehrcke Parallel Plates, of the same size, in quartz, for work in the ultra-violet.

(*O 4*) Price, in mount (Fig. O 3) ... ...

These can be used in front of a quartz spectrograph on the mount described below (Fig. O 12) which is then supplied with a quartz-fluorspar double (O 5), or a quartz-rocksalt triple (O 18) achromatic lens at an extra charge of ... ...

As quartz-fluorspar makes a better achromatic combination than quartz-rocksalt, the former will always be supplied whenever fluorspar of suitable quality is obtainable.

(*For the theory of the Lummer-Gehrcke parallel plate*, see *Annalen der Physik*, *Band* 10, 1903, *p.* 457.)

(*c*) **Fabry & Perot Etalon** (*see* Fig. O 6). The Etalon is constructed with a distance piece consisting of a hollow cylinder of fused silica between the plates (as described by H. C. Rentschler, *Astrophysical Journal*, December 1908).

The co-efficient expansion of fused silica being less than that of any other known material (0·000,000,59 per 1°C.—about one-seventeenth part of that of platinum) temperature alterations can be entirely avoided quite easily.

The plates are silvered by cathodic deposition from freshly electrolytically deposited silver. With silver films deposited in this manner the loss of light is less than by any other known method, and the necessary condition for sharply defined and bright

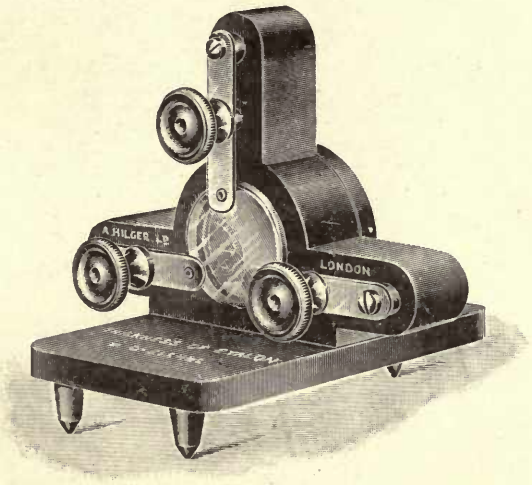

Fig. O 6.

intensity maxima is thus fulfilled. The plates are made slightly wedge-shaped in the usual manner to avoid the secondary interference systems caused by reflection at the unsilvered outer surfaces; but the angles of the wedges are the same in each plate, and they are so mounted that the total deviation caused by the Etalon is zero.

The appearance seen in the eyepiece when the Etalon is in position and correctly adjusted is as follows:—

(*a*) The lines of the spectrum are visible in the same positions as they would occupy were the Etalon removed; but of course far less bright.

(*b*) Each spectrum line is a diametrical strip of the ring system which would be produced by the Etalon if the field of view were filled with light of the wavelength of the line in question. The diameter of the ring system for each line can then be measured with a micrometer eyepiece.

The distance between the plates is about 10 mm., this distance producing a convenient ring system for measurement.

The thickness of the Etalon correct to 0·005 mm. is in each case engraved on the mount.

Length over all of Etalon and mount, 105 mm.

(*O 6*) Price, complete, with mount ... ...

(*O 7*) Price, with plates of quartz, nickelled by cathodic discharge, for ultra-violet work ... ...

For the method of working to obtain standard wavelengths by comparison with lines of accurately known wavelengths, see *papers by Lord Rayleigh,* Phil. Mag. [6], *May* 1906, *p.* 685; *and* [15] *April* 1908, *p.* 548.

NOTE.—*The height to the centre of the aperture in each of the above accessories is* 35 *mm.*

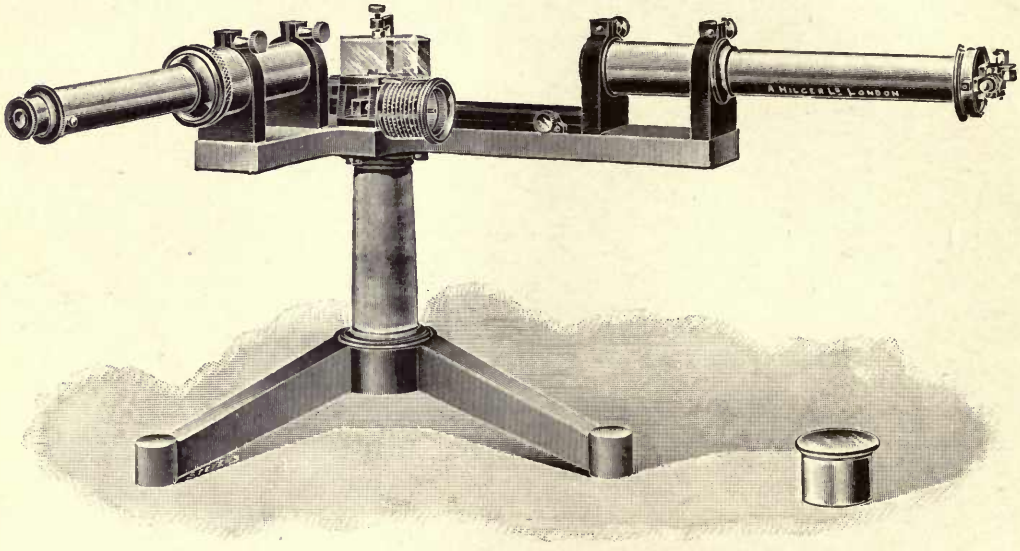

Fig. O 8.

THE HILGER WAVELENGTH SPECTROMETER (CONSTANT DEVIATION TYPE) MODIFIED FOR USE WITH THE ABOVE ACCESSORIES. (*See* Fig. O 8.)

(*See also separate leaflet describing the normal form.*)

The modifications are as follows :—

(1) The arm carrying the collimator is extended to make room for any one of the above accessories to be placed in position between the collimator and prism. A protective cover for the prism table is also supplied.

(2) The accessories stand on a brass plate capable of slight rotation by means of a milled head screw. This, together with a readily accessible levelling screw, provides the necessary adjustment for each of the accessories. Each of the accessories is in addition provided with screws for the levelling adjustment if it be desired to use them on the table of an ordinary Spectrometer.

(3) The aperture of the slit of the collimator is longer than that of the slit generally supplied with the W.L. Spectrometer, this being desirable for use with the Etalon. A second slit is attached to the main slit, the jaws running at right angles to it. This second slit can be rotated into or out of position as desired, and is necessary for use with the Echelon. The Echelon is mounted with the edges horizontal in the manner employed by Professor Michelson.

(4) An extra low-power eyepiece is supplied for use with the Etalon or Lummer-Gehrcke Plate.

(*O 8*) Price of Modified Wavelength Spectrometer, with extra dense prism, refractive index for D = 1·74, suitable for use with Lummer-Gehrcke Plate or Fabry & Perot Etalon.

(*O 9*) Well-made case with lock and key ... ...

(*O 10*) Price, if extended to suit Echelon of 12 plates, the plates being 10 mm. thick, and the effective aperture 29 mm. × 13 mm. ... ...

(The price of these Echelons, suitably mounted for this form of Spectroscope, is

Accurate micrometer eyepiece for measurement of the diameter of the ring system produced by the Etalon, or for employment with the Echelon and Lummer-Gehrcke Plate, with adapter for low-power eyepiece interchangeable with that for the usual eyepiece supplied.

(*O 11*) Price ... ...

(For sundry other accessories for the Wavelength Spectrometer, *see* Sections D and F.)

MOUNT TO TAKE THE ABOVE FABRY & PEROT ETALON, OR LUMMER-GEHRCKE PARALLEL PLATE, IN FRONT OF AN ORDINARY SPECTROSCOPE.

This mount (Fig. O 12) is made to suit the Fabry & Perot Etalons and Lummer-Gehrcke Parallel Plates described above.

The Etalon (as in the upper figure) or the Lummer-Gehrcke Parallel Plate (as in the lower figure) stands on a brass plate which is capable of slight rotation about a vertical axis by means of a milled head screw. This, together with a readily accessible levelling screw, provides the necessary adjustment for either of the accessories.

The rays from the source of light should be approximately collimated by a condensing lens. They then traverse the Lummer-Gehrcke Parallel Plate or Etalon, as the case may be; and an image of the resulting diffraction pattern is formed by an achromatic lens of about 5″ (130 mm.) focal length. This image consists, of course, of a number of superposed images produced by the various monochromatic radiations emanating from the source.

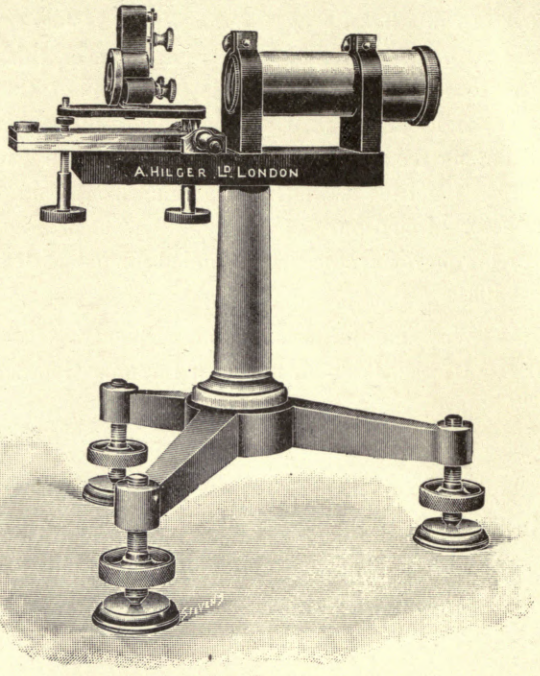

Fig. O 12 with O 4.

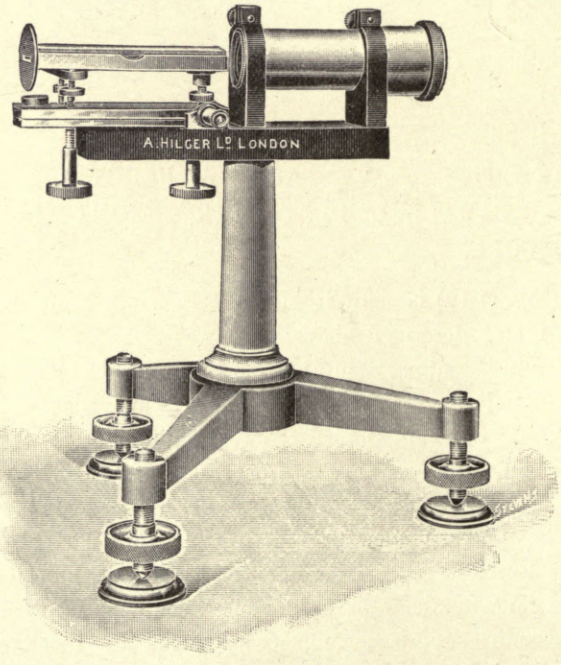

Fig. O 12 with O 3.

The spectroscope to be used in conjunction with this arrangement is then placed in train with the above apparatus so that the diffraction image falls on the slit. The jaws of the slit should be set vertical; and the dispersion of the spectroscope will then give the necessary separation of the overlapping diffraction images.

The apparatus is mounted on a substantial cast-iron tripod, with three levelling screws, and is suitable for use with any ordinary spectroscope.

(*O 12*) Price ... ...

Quartz-fluorspar double or quartz rocksalt triple achromatic lens, for use with the quartz Lummer Plate described on page O 2, fitted to the above mount.

(*O 5*, *O 18*) Price extra ... ...

Besides its use with the Lummer-Gehrcke Parallel Plate and Etalon, this piece of apparatus can also be employed, with the addition of a special collimator, to utilise the Echelon, described above, in combination with any ordinary spectroscope. The short tube with achromatic lens shown in Fig. O 12 must then be replaced by the special collimator in question, and the collimator of the ordinary spectroscope removed. The light from the source first passes through the special collimator, then through the Echelon, and then on to the prism of the spectroscope.

(*O 13*) Price of this special collimator (which is identical with that of the Modified Wavelength Spectrometer described above) ...

USEFUL ACCESSORIES FOR THE DEMONSTRATION OF THE ZEEMAN EFFECT BY MEANS OF THE LUMMER-GEHRCKE PARALLEL PLATE.

Small electro-magnet on raising and lowering stand, pole pieces adjustable from contact to ½″ (12½ mm.) apart; suitable for demonstrating the Zeeman effect with these Lummer-Gehrcke Parallel Plates. The current required is about 3 amperes when using an ordinary vacuum tube as the source of light. The lines are distinctly separated with these plates into triplets, etc.

(*O 14*) Price ... ...

Shutter eyepiece with bright pointer and double image prism, for Zeeman effect observations with the Lummer-Gehrcke Parallel Plate. By means of the shutter eyepiece the line under observation can be isolated, and the double image prism being turned into position, the components of the rays polarised in vertical and horizontal planes can then be observed side by side simultaneously.

The surfaces of the double image prism are protected by glass plates.

(*O 15*) Price ... ...

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Telephone—North 1677/8.
Cable Code—Western Union.

March 1920.

SECTION P.*

OPTICAL WORK.

Achromatic Object Glasses made from ordinary silicate glasses. Supplied mounted either in flanged, or in screwed cells.

Effective Aperture.	Types I. and II.		Type III.	Price in Cell.
	Focal Length.	Relative Aperture.	Focal Length.	
inches. mm.	inches. mm.		inches. cm.	
(*P 1*) 0·5 12·7	4·1 104	f/8	4·5 11·3	
(*P 2*) 0·8 20·3	5·7 145	f/8	6·2 15·8	
(*P 3*) 1·0 25·4	8·0 203	f/8	8·7 22·1	
(*P 4*) 1·25 31·7	11·2 284	f/9	12·2 30·9	
(*P 5*) 1·5 38·1	15·7 400	f/10	17·1 43·6	
(*P 6*) 1·9 48·2	21·9 556	f/11	23·8 60·6	
(*P 7*) 2·5 63·5	30·6 777	f/12	33·3 84·6	
(*P 8*) 3·3 83·8	42·8 1,087	f/13	46·6 118·0	
(*P 9*) 4·3 109·2	60·0 1,524	f/14	65·4 166·0	

The lenses are made in three types.

Type I., for visual spectrum work, corrected for spherical aberration in axis, and achromatised for the extreme visible red and violet.

Type II., for spectrum photography from wavelength 800 $\mu\mu$ to wavelength 350 $\mu\mu$, achromatised for the violet.

Type III., for ordinary telescope work, achromatised for C and F.

The above focal lengths may vary from time to time by as much as 3 per cent.

Ordinary doublet Lenses to other specified sizes, focal lengths, or other special specifications, price 30 per cent. extra.

Prisms for Spectroscopic Work.

The following expressions give the prices of single prisms of 60° angle made to order :—

h is the height of the prism in centimetres.

l is the length of the refracting face in centimetres.

Refractive Index for D.	Price in Shillings.	The Expressions may be used up to (centimetres)		Glass always in stock to cut Prisms of (centimetres)	
		h	l	h	l
1·58 to 1·62	$0{\cdot}33hl^2+17$	13	18·5	10	13
1·65	$0{\cdot}36hl^2+17$	10·5	16	8	11
1·74	$0{\cdot}62hl^2+17$	8	10·5	6	8

The above prisms have rectangular refracting surfaces.

Prisms of refractive indices below 1·58 are supplied at the same price as those of 1·58. Higher refractive indices than 1·74 are not recommended except for special purposes. The expressions may be employed up to the sizes given in the third column, and prisms exceeding the dimensions there given will be quoted for on application.

Glass is *always* kept in stock to cut prisms of about the sizes given in the fourth column, and *usually* to cut prisms of the sizes given in the third column.

The prices are for prisms of the highest quality. The angles are made accurate to within 10′. If a greater accuracy be required, for an accuracy of ±15″ add 25 per cent., with a minimum charge for the increased accuracy of 10s.; for an accuracy of ±5″ add 75 per cent., with a minimum charge for the increased accuracy of 25s.

Note (*March* 1920).—*All the above prices are increased by approximately* 140 *per cent.*

The following sizes are stocked in refractive indices from 1·58 to 1·65, and are supplied, as will be seen, at a considerable reduction on the above scale of prices. They are in all respects equal in quality to the above prisms, but are only supplied in the sizes and of the refractive indices as stated. The surfaces are rectangular.

Light Flint. ref. ind. for D = 1·58 to 1·62 about.			Dense Flint. ref. ind. for D = 1·63 to 1·65 about.		
Length of Face.	Height of Prism.	Price.	Length of Face.	Height of Prism.	Price.
in. mm.	in. mm.		in. mm.	in. mm.	
(*P 10*) 1¼ 32	1 25		(*P 14*) 1⅜ 35	1 25	
(*P 11*) 1⅝ 42	1¼ 32		(*P 15*) 1¾ 44	1¼ 32	
(*P 12*) 2 51	1½ 38		(*P 16*) 2⅛ 54	1½ 38	
(*P 13*) 2⅜ 60	1¾ 44		(*P 17*) 2½ 64	1¾ 44	

It will be noted that the lengths of the surfaces in the above prisms are greater than the heights, and that the ratio of length of surface to height becomes greater with the refractive index. By this means a more satisfactory effective aperture is obtained.

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Right-Angled Prisms.

Length of Square Cathetus Surface.	Price.
(*P 18*) 10 mm.	
(*P 19*) 15 ,,	
(*P 20*) 20 ,,	
(*P 21*) 25 ,,	
(*P 22*) 30 ,,	
(*P 23*) 35 ,,	
(*P 24*) 40 ,,	
(*P 25*) 45 ,,	
(*P 26*) 50 ,,	
(*P 27*) 55 ,,	
(*P 28*) 60 ,,	

Larger sizes quoted on application.

The above right-angled prisms are of the very finest quality; of white, clear, and thoroughly annealed crown. The definition is guaranteed, and all the angles are accurate to within 5′. If a greater accuracy of angles be required, for an accuracy of $\pm 10''$ add 25 per cent., for an accuracy of $\pm 5''$ add 75 per cent. to the above prices.

Diagonal Planes, of guaranteed quality, silvered. (These planes are so edged as to reflect a circular beam of light when set at an angle of 45°.)

Diameter of minor axis of surface.	Price.	Diameter of minor axis of surface.	Price.
(*P 29*) $1\frac{1}{8}$ inches.		(*P 33*) 2 inches.	
(*P 30*) $1\frac{1}{4}$,,		(*P 34*) $2\frac{1}{2}$,,	
(*P 31*) $1\frac{1}{2}$,,		(*P 35*) 3 ,,	
(*P 32*) $1\frac{3}{4}$,,		(*P 36*) $3\frac{1}{2}$,,	

Diagonal planes can be made to fit existing mounts at the same scale of prices.

Plane Mirrors, of guaranteed quality, for Siderostats, Heliostats, and general purposes. The price includes silvering. The price for speculum metal mirrors is 50 per cent. higher.

Diameter in inches.	Price.	Diameter in inches.	Price.
(*P 37*) 1		(*P 45*) 8	
(*P 38*) $1\frac{1}{2}$		(*P 46*) 9	
(*P 39*) 2		(*P 47*) 10	
(*P 40*) 3		(*P 48*) 11	
(*P 41*) 4		(*P 49*) 12	
(*P 42*) 5		(*P 50*) 13	
(*P 43*) 6		(*P 51*) 14	
(*P 44*) 7		(*P 52*) 15	

For concave mirrors (if of radius not less than 15 times the diameter), add 25 per cent. to the above prices. Concave mirrors of larger sizes, or with radii less than 15 times the diameter, quoted for on application.

Galvanometer Mirrors, of the highest optical perfection, to the following dimensions :—

Diameter.	Thickness.	Radius of Curvature.
10 mm. (or anything smaller)	0·5 mm.	36 inches, or 1,000 mm.

(*P 53*) (1) Of glass, palladinised on the front. Price, each ... ...

(*P 54*) (2) Of fused silica, platinised on the front. (These can be soldered without damage.) Price, each ... .

Plane Mirrors, up to 10 mm. dia., at the same prices as above.

Concave Mirrors, up to 10 mm. dia., of other radii than those given, can be supplied at double the above prices.

Larger sizes quoted for if required.

Cornu Prisms of Quartz.

Refracting Angle 60°.

These prisms are accurately cut with respect to the axis. They are composed of two prisms of right and left rotation quartz respectively, each of 30° angle.

We have recently introduced an important improvement in the construction of these prisms, viz., the setting of the two component prisms into optical contact at the interface. This procedure results in

(1) Greater optical perfection.

(2) Removal of double image caused by reflection between the two inside surfaces, without the necessity of any liquid between the two surfaces.

(3) A gain in light transmitted.

(4) Greater convenience of handling.

Following our usual procedure with 60° prisms we quote for a length of face greater than the height of prisms. We cannot, however, in the case of quartz prisms always adhere quite rigidly to the sizes stated.

	Length of external faces.		Height of prism.		Price.
	mm.	in.	mm.	in.	
(*P 55*)	25	1	19	$\frac{3}{4}$	
(*P 56*)	32	$1\frac{1}{4}$	25	1	
(*P 57*)	42	$1\frac{5}{8}$	32	$1\frac{1}{4}$	
(*P 58*)	50	2	38	$1\frac{1}{2}$	
(*P 59*)	57	$2\frac{1}{4}$	44	$1\frac{3}{4}$	
(*P 60*)	65	$2\frac{5}{8}$	41	$1\frac{5}{8}$	
(*P 61*)	65	$2\frac{5}{8}$	50	2	
(*P 62*)	82	$3\frac{1}{4}$	52	$2\frac{1}{8}$	
(*P 63*)	98	4	59	$2\frac{3}{8}$	
(*P 64*)	110	$4\frac{3}{8}$	70	$2\frac{3}{4}$	

QUARTZ LENSES.

Price of Quartz Lenses, unmounted, accurately cut with the crystallographic and optical axes coincident.

	Clear Aperture.		Price.
	in.	mm.	
(*P 65*)	1	25·4	... ...
(*P 66*)	$1\frac{1}{4}$	32	... ...
(*P 67*)	$1\frac{1}{2}$	38	... ...
(*P 68*)	$1\frac{3}{4}$	44	... ...
(*P 69*)	2	51	... ...
(*P 70*)	$2\frac{1}{4}$	57	... ...
(*P 71*)	$2\frac{1}{2}$	64	... ...

The above prices are for Lenses of the finest definition, with carefully selected curves, the focal length for W.L. 400 $\mu\mu$ being not less than 10 times the diameter.

Lenses of larger angular aperture up to F/4·5 can be supplied figured to correct the spherical aberration for points on the axis at the prices obtained by multiplying the prices in the above table by the factor

$$1 + \left(\frac{10 - N}{N - 2}\right)$$

where N is the focal length divided by the aperture.

Condensing Lenses of Quartz, see *Section F.*

Plane Parallel Glass.

(*First quality surfaces only supplied.*)

This is stocked in the following thicknesses:—
1 mm., 2 mm., 3 mm., $4\frac{3}{4}$ mm., $7\frac{1}{2}$ mm., 10 mm.

1 mm. thick Plane Parallel Glass, accuracy of parallelism about 10 seconds.
(*P 91*) Price in shillings = × area in square cms. + .
up to 25 mm. in the longest dimension.

2 mm. thick Plane Parallel Glass, accuracy of parallelism about 6 seconds.
(*P 91*) Price in shillings = × area in square cms. + .
up to 40 mm. in the longest dimension.

3 mm. thick Plane Parallel Glass, accuracy of parallelism about 3 seconds.
(*P 91*) Price in shillings = × area in square cms. + .
up to 50 mm. in the longest dimension.

$4\frac{3}{4}$ mm. thick Plane Parallel Glass, accuracy of parallelism about 3 seconds.
(*P 91*) Price in shillings = × area in square cms. + .
up to 65 mm. in the longest dimension.

$7\frac{1}{2}$ mm. thick Plane Parallel Glass, accuracy of parallelism about 3 seconds.
(*P 91*) Price in shillings = × area in square cms. + .
up to 100 mm. in the longest dimension.

10 mm. thick Plane Parallel Glass, accuracy of parallelism about 3 seconds.
(*P 91*) Price in shillings = × area in square cms. + .
up to 150 mm. in the longest dimension.

Crystalline Quartz of like accuracy cut perpendicular to the axis.
Prices, $2\frac{1}{2}$ times the above.

CONSTANT DEVIATION PRISMS (Fig. P 72), as used in the Hilger Constant Deviation Spectrometer (see p. D 1).

Refractive Index for D.	Size of Equivalent 60° prism face.				Price.
	Length of Face.		Height.		
	in.	mm.	in.	mm.	
(*P 72*) 1·65	$1\frac{5}{8}$	42	$1\frac{5}{16}$	34	
(*P 73*) 1·74	$1\frac{5}{8}$	42	$1\frac{5}{16}$	34	
(*P 74*) 1·65	$2\frac{5}{8}$	65	$1\frac{3}{4}$	44	

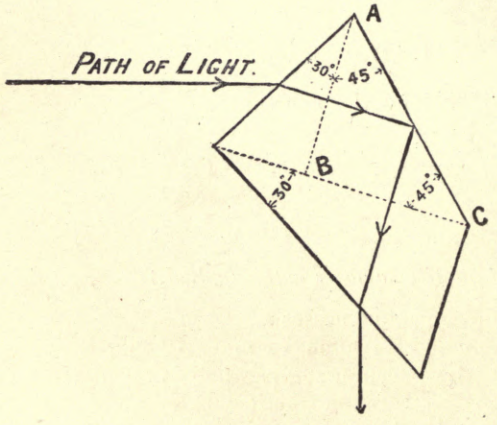

Fig. P 72.

Prisms of Rocksalt, up to 6 cm. long face. Can be priced from the following formula :—Price in Shillings = (*h* and *l* being the height and the length of face in centimetres).

Lenses of Rocksalt.

Focal length for D not less than five times the diameter, second quality surfaces.

	Diameter.		Price.
	inches.	mm.	
(*P 80*)	1	25	
(*P 81*)	$1\frac{1}{4}$	31	
(*P 82*)	$1\frac{1}{2}$	38	
(*P 83*)	$1\frac{3}{4}$	44	
(*P 84*)	2	51	
(*P 85*)	$2\frac{1}{4}$	57	
(*P 86*)	$2\frac{1}{2}$	63	
(*P 87*)	$2\frac{3}{4}$	70	
(*P 88*)	3	76	

First quality lenses of Rocksalt, focal length for D not less than $\frac{1}{7}$ the diameter, curves such as to give minimum spherical aberration for W.L. 10 μ, price $2\frac{1}{2}$ times the above.

(*P 89*) Fresnel biprisms $1\frac{1}{4} \times \frac{3}{4}$ inch, 179° angle, ...

ADAM HILGER, Ltd., 75a Camden Road, London, N.W. 1

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March 1920.

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The very greatest care is exercised in packing, which is charged at cost price, and ADAM HILGER, LTD., cannot hold themselves responsible for injuries, which should be claimed for from the carrier. Cases should always be examined on arrival in presence of the carman for any external signs of damage, and his recognition of any such damage obtained.

Cases returned carriage paid and in good condition will be credited at two-thirds.

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